The AMSAT® Journal

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Live from Atlanta, its PCsat live! Bob Bruninga, WB4APR gives AMSAT symposium participants a real-time demo of PCsat. By happenstance, PCsat was passing over Atlanta at the beginning of WB4APR's presentation. Launched just ten days earlier, PCsat is providing APRS service to Radio Amateur operators around the world. See page 18 for additional details on PCsat. (photo by Dick Daniels, W4PUJ)

Atlanta Welcomes AMSAT

The 19th AMSAT Annual Meeting and Space Symposium was held 07-08 October 2001 at the Holiday Inn Select in Decatur, Georgia. Over 150 participants attended the meeting and were presented with a diversity of Amateur Radio satellite technology and development. As usual with most symposiums, this meeting had an international flair with participants coming from Bermuda, Canada, Germany, Japan, Mexico, South Africa, and the United Kingdom. Thanks to Steve Diggs, W4EPI and his organizing committee for putting together a great conference.

Numerous technical papers were presented during the conference that were also published in proceedings that were provided to all participants. Among papers presented were:

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The AMSAT Journal staff is always interested in article submissions. Whenever possible, text should be on IBM compatible diskettes with hardcopy or original photographs or figures. AMSAT-NA reserves the right to select material for *The AMSAT Journal* based on suitability of content and space considerations. The editors of this publications are volunteers giving freely of their talents, time, and efforts to produce *The AMSAT Journal*.

Apogee View

The Annual meeting in Atlanta has both come and gone, and many thanks are due to those who hosted and participated in a very successful meeting. One of my thoughts about that meeting was that it was wonderful to see so many of you there, in light of the tragedy of 11 September 2001.

In this time of stress, Amateur Radio has a lot to give and many roles to perform. The more obvious ones are those of acting as a backup communications system should that be necessary, both on the national systems and the international systems and remembering that our satellite technologies provide messaging capabilities that are independent of normal propagation. Those stations that have their own generators can even be totally independent of the public electricity supplies. We must make sure that our emergency organizations are aware of our capabilities, and we must not turn down any serious requests for help from them.

In addition, many of us who enjoy this hobby, find relaxation in making contacts through the satellites and other means of Amateur Radio, and it is always important during times of stress to get refreshed and relaxed. What better way than to practice our communications art, and to make sure that all of our equipment is working well, ready for any task should that become necessary.

Many members of AMSAT are also active listeners to the shortwave bands as well as the amateur and satellite bands. Keep those antennas and radios tuned listening for problems that should be reported to the appropriate authorities. As we know not all radio communications are legitimate and it is possible that we could intercept, and be able to provide valuable information to the Pentagon. While it may sound far fetched I am personally aware of Amateur Radio assistance to the Pentagon having taken place during the Gulf War.

Remember that while the US is the major player in this war against terrorists, many other countries are also involved and fully supportive and committed to see the right outcome, and that AMSAT members around the world have a role to play.

Our hobby can be of material assistance in this long war. Thus building and launching of satellites can be considered a significant help in the battle that we have no option but to win!

Your support of AMSAT by a donation or a term commitment through the Presidents Club will be appreciated.

May I end by wishing you all a very Merry Christmas, Happy Hanukah, and a very productive NewYear.

73,
Robin Haighton, VE3FRH, President ■

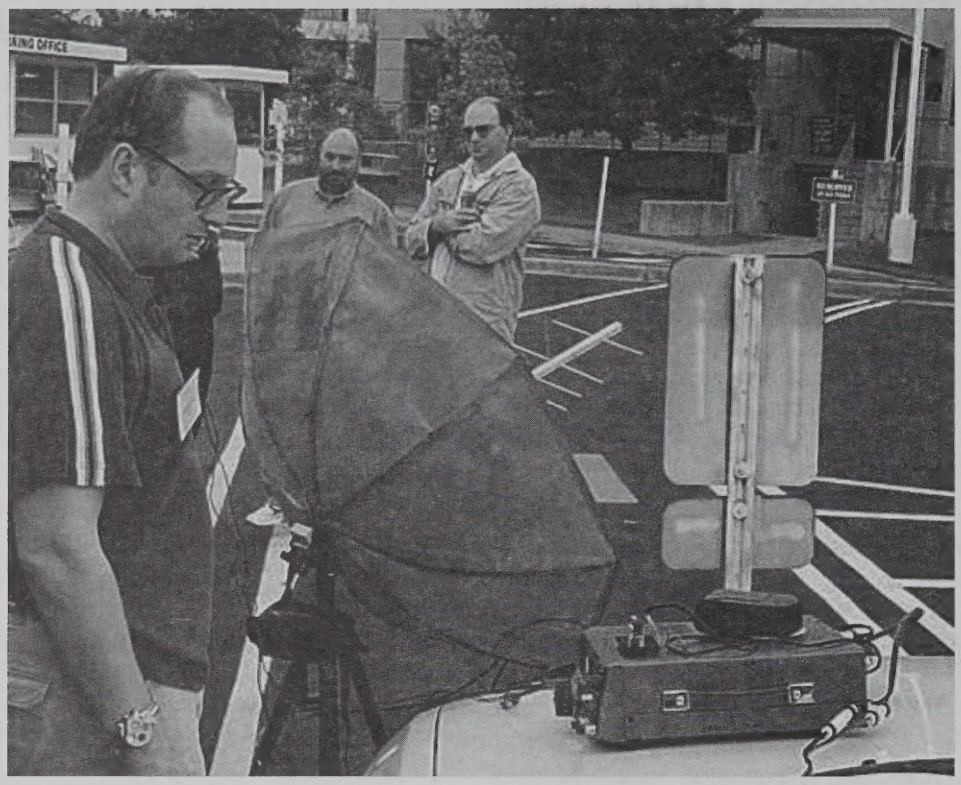
Condolences for the United States Conveyed to AMSAT-NA

To all our friends in the US, may I on behalf of the Committee and Membership of AMSAT-UK express our shock, horror and great sadness at the events of yesterday in New York and Washington, DC. Our hearts and thoughts are with all those affected by this terrible act. 73, **Prof. Martin Sweeting OBE , FREng, FRS, G3YJO, Chairman, AMSAT-UK**

Dear Fellow US Amateurs: Via the commercial satellites we have had continuous television coverage of the tragic events in New York and Washington as they unfolded. Since 2 AM this morning our time, I have watched in utter disbelief as the reports came in - it has been a long morning and will be an even longer day. The term surreal is being used in the TV commentaries and that same feeling pervades us so far away. While we share some disruption to our daily lives we cannot grasp the scale of your tragedy. From all our members; we try to understand the grief so many are suffering and to come to grips with the changes ahead for us all. Our sympathy and support to all affected by this shocking tragedy. 73, **Terry Carrell, ZL3QL, President AMSAT-ZL**

All the members of AMSAT-DL are sorry and shocked about the totally inhumane events in New York and Washington. We thus would like to reach out and let know all the American people, and our friends of AMSAT in particular, that we feel and suffer with you. Helpless as we are, we cannot but take these events as yet another encouragement to contribute our little share to promote worldwide understanding and to eradicate mindless hate. **Peter Gülzow, DB2OS; Frank Sperber, DL6DBN; Karl Meinzer, DJ4ZC**

[Continued on page 9]



Have AO-40 set up, will travel! Howard Long, G6LVB travelled to Atlanta from the United Kingdom with his own AO-40 setup that included a Kenwood 2000, a homemade 2.4GHz dish antenna (made from an umbrella and copper cloth), 70cm Arrow antenna and downconveter. Several contacts were made in the parkinglot. (photo by Bruce Paige, KK5DO)

[Continued from page 1]

AO-40 Operations

- *AO-40 Laser Ground Station Design*, Joe Fitzgerald, KM1P
- *AO-40 Status Discussions*, AO-40 Project Team
- *AO-40 Telemetry from Generation to Interpretation*, Gould Smith, WA4SXM
- *A Helix Feed for Surplus MMDS Antennas*, Jerry Brown, K5OE
- *Yet Another Helix Experiment – Plus Edition*, Jerry Brown, K5OE

Proposed Satellites and Design

- *An Efficient Digital Mode Transponder*, Phil Karn, KA9Q
- *Project JJ Description*, Project JJ Team
- *Satellite Links: Things You Should Know*, Jan King, W3GEY
- *USNA Cubesat Ideas*, Bob Bruninga, WB4APR

Satellite Operations

- *2001: A Moonbounce Oddessy*, Paul Shuch, N6TX
- *ARISS Mission Status Report*, Frank Bauer, KA3HDO
- *Easy Trak Rotator Control Update*, Steve Bible, N7HPR
- *A How to For Microwave Satellites*, Ed Cole, AL7EB
- *Instant Tune Update*, Tony Monteiro, AA2TX
- *PCSAT: A Digital Satellite for Everyone*, Bob Bruninga, WB4APR
- *Satellite Contract Awards*, Bruce Paige, KK5DO
- *Software Defined Radios*, Steve Bible, N7HPR

For those who could not attend the Atlanta symposium, Bruce Paige, KK5DO recorded all presentations which are available as audio files for listening and downloading via *www.amsatnet.com*. Many thanks to Eric Crottrell, WB1HBU for providing the sound board and computer for encoding the presentations during the symposium.

On Saturday evening, the annual banquet was held. After dinner, Stacey Mills, W4SM gave a very interesting talk on the continuing dedicated efforts to command and control the AO-40 satellite. During his presentation, Stacey demonstrated various software programs that the command and control team uses to manage AO-40. After W4SM's presentation, numerous awards were presented to AMSAT members for their contributions during the past year. Of special note was the first presentation of the *President's Award* that is given to a member who has made significant contributions to AMSAT. The first winner of the *President* Award was presented to Dick Jansson, WD4FAB for his contributions to the design of AO-10, AO-13, and AO-40.

Also, many (nearly all) participants took home prizes that were donated by many generous sponsors. Grand prize winners were Linda McMillan, KF4SMS: Icom IC-901H; William Reed, WD0ETZ: Kenwood TH-D7; and Ed Rojowski, N8GZL: Bird Wattmeter.

Several other special sessions were held at the symposium. On Friday evening, Gould Smith, WA4SXM conducted a two-hour beginner's guide to satellite ham radio. At this presentation, local area hams learned about the basic fundamentals of amateur satellite operations. On Saturday morning, a 24 GHz working group breakfast was held to discuss operation of AO-40's 24 GHz band (for additional details on AO-40 24 GHz operations see: *http://www.sunsunsun.net/ao40/*. On Sunday morning, the Area Coordinators' Breakfast was held where various techniques and strategies were presented to promote AMSAT at the grassroots level including local hamfests and Amateur Radio club meetings. Later, Hans Van de Groenendaal, ZS6AKV and Ray Soifer, W2RS hosted an IARU meeting on satellite issues. Of key discussion was a suggested approach to coordinate the selection and establishment of satellite frequencies for new satellites.

On Sunday mid-morning, a meeting of the AMSAT Board of Directors began in which a variety of AMSAT business was discussed. The minutes of this meeting will be posted in the January/February 2002 issue of *The AMSAT Journal*.

Now is the time to make plans to attend the 20th AMSAT Annual Meeting and Space Symposium that will be held at the Lockheed Recreational Area in Fort Worth, Texas in October 2002. Keith Pugh, W5IU and the Lockheed Amateur Radio Club are looking forward to hosting the event. Stay tuned to ANS and *The AMSAT Journal* for additional details on this meeting. See y'all in Fort Worth

where the West begins!

2001 AMSAT Awards
AMSAT Symposium

Alan Adamson, NE1H: In grateful appreciation for your work as RF Communications Engineer for the 2001 AMSAT Annual Meeting and Space Symposium. Your dedicated service and hard work in helping with this task for our annual gathering is noted with thanks.

John Clowe, W4ZPG: In grateful appreciation for your work as Prize Chairman for the 2001 AMSAT Annual Meeting and Space Symposium. Your dedicated service and hard work in gathering prizes for this event is noted with thanks.

Diana Diggs: In grateful appreciation for your work as Outside Activities Coordinator for the 2001 AMSAT Annual Meeting and Space Symposium. Your dedicated service and hard work in handling the myriad details associated with this important aspect of our annual gathering is noted with thanks.

Steve Diggs, W4EPI: In grateful appreciation for serving as host for the 2001 AMSAT Annual Meeting and Space Symposium. Your dedicated service and hard work in coordinating the myriad details of our annual gathering is noted with thanks.

Sandy Donahue, W4RU: In grateful appreciation for your work as ARRL Liaison for the 2001 AMSAT Annual Meeting and Space Symposium. Your dedicated service and hard work in this role is noted with thanks.

Stan Halter, KE4VGZ: In grateful appreciation for your work as Local Club Coordinator for the 2001 AMSAT Annual Meeting and Space Symposium. Your dedicated service and hard work in handling this important task for our annual gathering is noted with thanks.

Les Scofield, W4SCO: In grateful appreciation for your work as Special Event Station Manager for the 2001 AMSAT Annual Meeting and Space Symposium. Your dedicated service and hard work in handling this aspect of our annual gathering is noted with thanks.

Virginia Slack, KA4DDQ: In grateful appreciation for your work as Registration Coordinator for the 2001 AMSAT Annual Meeting and Space Symposium. Your dedicated service and hard work in handling this very important aspect of our annual gathering is noted with thanks.

AO-40/Phase 3D

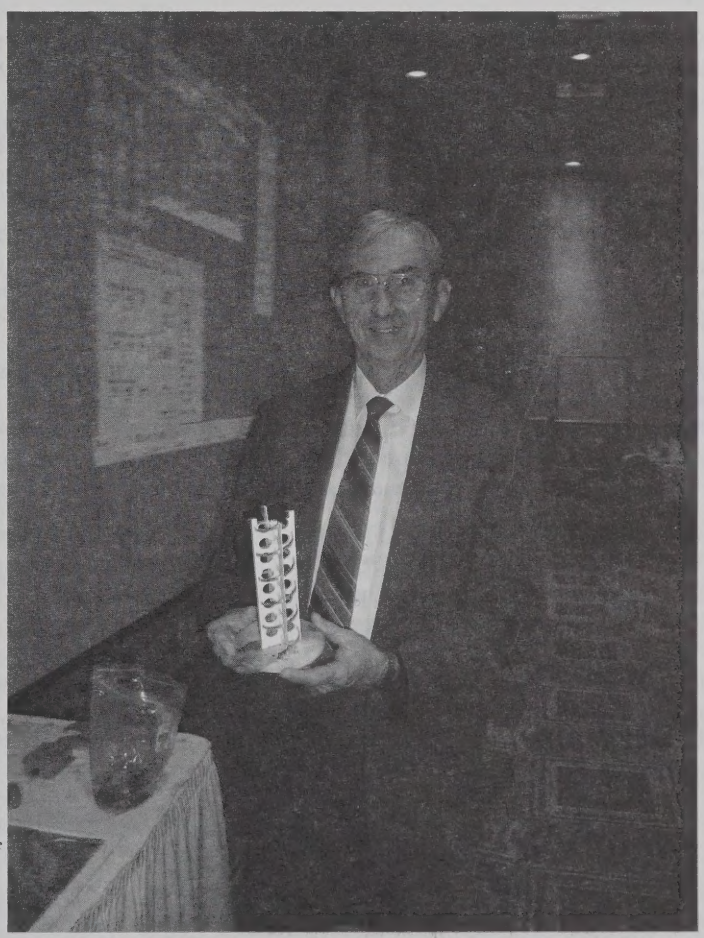
Ian Ashley, ZL1AOX: Thank you Ian for presenting all AMSAT organizations and their members with the best Christmas present anyone could have asked for. Your discovery that AO-40 was alive and well on Christmas Day 2000, brought joy to all. Thank you, as well, for the many hours of work you have put into the AO-40 recovery process. Your efforts are certainly appreciated.

Mike Chepponis, K3MC: Because of a parts failure on the 10GHz transmitter of Phase 3D, you left an important company meeting, searched and found and purchased replacement parts. This enabled the replacement parts to be personally carried to Miami and then to Kourou. The satellite was launched with all systems working.

John Conner, NJ0C: Following a parts failure in the Phase 3D 10GHz transmitter, you hand-carried replacement parts to Miami enabling them to get to Kourou prior to the launch. Your commitment helps assure that the satellite was able to be launched with all systems working. Thank you for your valuable assistance at this critical point.

Chuck Green, N0ADI: For generous contribution of your time and effort during the Phase 3D launch campaign in the Fall of 2000 at the ESA launch facility, Kourou, French Guiana. Your willingness to sacrifice your personal time for this endeavor is greatly appreciated by hams all over the world. Thanks to the launch support team leadership role you accepted, the spacecraft was fully integrated and all systems operational at lift-off. To the great joy of all who followed the proceedings throughout the world, the Ariane 5 launch vehicle placed Phase 3D into a perfect GTO orbit. Please accept this as a small token of appreciation from those who contributed to, and worked on, this magnificent accomplishment for Amateur Radio.

Peter Guelzow, DB2OS: Peter, on behalf of AMSAT organizations throughout the world, thank you for all the work you have put into AO-40. You assumed the role of the AMSAT manager at Kourou



AMSAT VP of Engineering Stan Wood, WA4NFY displays a prototype of the AO-40 S-Band antenna that is similar to the antenna that is currently in operation on the satellite. (photo by Bruce Paige, KK5DO)

Birthday greetings were conveyed at the Annual Banquet to John Shew, N4QQ and Symposium Coordinator Diana Diggs. (photo by Dick Daniels, W4PUJ)

under difficult conditions, and completed a successful launch campaign. Since then, you have worked tirelessly as one of the satellite command station team members, to bring AO-40 back to life when things went wrong. Your dedication to the amateur satellite community, and to AO-40, is greatly appreciated.

James R. Miller, G3RUH: Thank you James for all the hours of work you have put into AO-40 during the recovery operations. Your skill as a satellite controller has greatly aided in the understanding of the satellite's problems and in finding solutions that have resulted in recovery of many of the spacecraft's systems.

Stacey Mills, W4SM: Thank you Stacey for all the hours you have put into AO-40 as a controller, during the recovery operations as well as your role during the launch campaign at Kourou. Your efforts are appreciated by all AMSAT organizations and their members who have participated in the operation of the satellite, or expect to in the future. In addition, the informative clear and factual bulletins you post to AMSAT-BB have been very beneficial in keeping everyone informed as to progress in bringing the satellite into operation.

Graham Ratcliff, VK5AGR: Thank you Graham for the countless hours you have put into AO-40 during the recovery operations. The number of times you have worked late at night and into the next morning are certainly appreciated by the members of all the AMSAT organizations throughout the world.

Jim White, WD0E: For generous contribution of your time and effort during the Phase 3D launch campaign in the Fall of 2000 at the ESA launch facility, Kourou, French Guiana. Your willingness to sacrifice your personal time for this endeavor is greatly appreciated by hams all over the world. Thanks to your work, and that of the others making up the launch support team, the spacecraft was fully integrated and all systems operational at lift-off. To the great joy of all who followed the proceedings throughout the world, the Ariane 5 launch vehicle placed Phase 3D into a perfect GTO orbit. Please accept this as a small token of appreciation from those who contributed to, and worked on, this magnificent accomplishment for Amateur Radio. Your support of the recovery effort is also gratefully acknowledged and much appreciated.

Paul Wilmott, VP9MU: For actively soliciting, collecting and assembling AO-40 telemetry data. Your dedicated efforts to archive this material significantly aided the command stations in their recovery operations. In addition, your making the data available via the Internet has aided greatly to the worldwide amateur community's understanding of the difficulties encountered by the spacecraft during the propulsion incident of December 2000. This understanding has proven vital to building trust between those actively working to make AO-40 available to all, and the general amateur community. AMSAT expresses its appreciation and thanks for your notable efforts.

Bob Davis, KF4KSS; Michael Fletcher, OH2AUE; Wilfried Gladisch; Freddy de Guchteneire, ON6UG; Hermann Gunter; Dick Jansson, WD4FAB; Lyle Johnson, KK7P; Mirek Kasal, OK2AQK; Rick Leon, KA1RHL; Thomas Maier; Lou McFadin, W5DID; Konrad Muller, DG7FDQ; Jay Ramdas; Martin Reihle; Heike Straube;Horst Wagner, DB2ZB received plaques with this citation: For generous contribution of your time and effort during the Phase 3D launch campaign in the Fall of 2000 at the ESA launch facility, Kourou, French Guiana. Your willingness to sacrifice your personal time for this endeavor is greatly appreciated by hams all over the world. Thanks to your work, and that of the others making up the launch support team, the spacecraft was fully integrated and all systems operational at lift-off. To the great joy of all who followed the proceedings throughout the world, the Ariane 5 launch vehicle placed Phase 3D into a perfect GTO orbit. Please accept this as a small token of appreciation from those who contributed to, and worked on, this magnificent accomplishment for Amateur Radio.

Communications and Information

Jill Barkan: In appreciation for your efforts in assisting AMSAT to develop an effective business development strategy. Your generous sharing of your experience, insight, and knowledge has allowed AMSAT to realign its business activities to accomplish our long-term goals.

Ed Krome, K9EK: In appreciation of your efforts in updating *Mode 'S' The Book* for distribution at the Dayton Hamvention and other

venues. Your efforts enabled AMSAT to effectively provide current information on a variety of spacecraft for veteran satellite operators as well as new users.

Walt Rader, WA3DMF: In recognition of your significant efforts as the AMSAT QSL Bureau Manager and Coordinator of the Satellite Communicators' Club for many years. Your efforts to organize and maintain the QSL Bureau and process applications for the Communicators' Club certificate have been greatly appreciated. AMSAT looks forward to your further contributions and successes. The Officers, Board of Directors and membership of AMSAT wish to express their appreciation and thanks for your efforts.

Barbara Saragovitz: In appreciation of your help moderating and facilitating AMSAT's workshop convened to develop a strategy and business development plan for the organization. Your patient efforts to help the diverse personalities present to define and articulate AMSAT's vision and for the future are greatly appreciated.

Mike Scarcella, WA5TWT: In recognition of your significant efforts as AMSAT Awards Manager during the 1990's. Your efforts to promote, organize and maintain the many aspects of AMSAT's Awards Program have been greatly appreciated. AMSAT looks forward to your further contributions and successes.

Mike Seguin, N1JEZ: In appreciation of your efforts in updating *Working the Easy Sats* for distribution at the Dayton Hamvention and other venues. Your significant efforts allowed AMSAT to effectively furnish information on a variety satellites, especially to new users.

Gould Smith, WA4SXM: In appreciation of your efforts in updating the *AMSAT-NA Digital Satellite Guide and the Analog Satellite Operating Guide* for distribution at the Dayton Hamvention and other venues. Your significant effort allowed AMSAT to effectively provide up-to-date information on a variety satellites for current and new users.

Bill Tynan, W3XO: In appreciation of your efforts to update the *AMSAT Frequency Guide* for distribution at the Dayton Hamvention and other venues. Your efforts allowed AMSAT to effectively furnish current information on a variety of amateur spacecraft for old and new satellite operators alike.

Roy Welch, W0SL: For dedicated service to AMSAT as the Software Exchange Manager. You kept up to date the software on the AMSAT web site, making possible its availability for downloading. In addition, you served as an Area Coordinator for the past several years. You are also AMSAT's resident guru on the WISP software program and have provided much needed special support for recent Polar expeditions. AMSAT wishes to express its appreciation and thanks for all of your efforts over the years.

Jim Weisenberger, AA7KC: For keeping the AMSAT News Service up to date on the status of the digital satellites. Your weekly input is an integral part of the weekly ANS news published on the AMSAT web page. This information is invaluable to hams all over the world in finding the current status of digital satellites. On behalf of AMSAT, please accept our thanks for a job well done.

Satellite Operations

Susan Helms, KD7NHZ: For your enthusiasm, patience and perseverance to bring Amateur Radio to the world, AMSAT hereby presents you with this award. You were very active from the beginning of your stay aboard the International Space Station and continued your efforts during the 2001 Field Day event, June 23rd and 24th by operating NA1SS in Class 1A-Battery. You took special time away from your personal needs to make hundreds of contacts with hams worldwide. For this, you have shown that Amateur Radio has no bounds and makes you a global friend to all. The Officers, Board of Directors and membership of AMSAT wish to express their appreciation and thanks for your efforts.

The Huntsville Amateur Radio Club, K4BFT: First Place finish in the 2001 AMSAT Field Day event on June 23rd & 24th. ARRL operating class 5A with emergency power and portable operation.

Randy Kohlwey, N7SFI: In recognition of your significant efforts to promote mobile and portable amateur satellite activity by operating from many Maidenhead grid squares. This has helped other hams in their quest for the VHF/UHF Century Club (VUCC) Award. Please accepts the AMSAT's thanks for your continuing efforts.

Nick Pugh, K5QXJ: For contribution of communication facilities in support of the AMSAT Launch Information Net during the Phase 3D launch. Your support made it possible for radio amateurs throughout the world to follow this important event live. AMSAT also appreciates similar support you provided for several Board of Directors telecons, contributing greatly to the organization. Please accept the thanks of the AMSAT Board of Directors, Offices and members for your invaluable help.■

Straight Key Night on OSCAR, Ray Soifer, W2RS

You are cordially invited to participate in the 30th annual Straight Key Night on OSCAR, conducted by AMSAT-NA for radio amateurs throughout the world. It's entirely informal: no rules, no scoring and no need to send in a log. Just operate CW using a straight hand key through any OSCAR (including OSCAR Zero, the moon) on 01 January 2002 between 0000 and 2400 UTC.

In keeping with the fun nature of this event, please nominate, from among those you worked, the operator with the best fist. Nominations may be sent to me by e-mail at w2rs@amsat.org, by packet radio to W2RS @ WA2SNA.NJ.USA.NA, or by ordinary mail to my Callbook address. All those receiving nominations will be recognized in an ANS bulletin in early February, and in *The AMSAT Journal.* ■

Many Thanks to the Following for Donating AMSAT Banquet Prizes

Grand Prizes

IC-910H via ICOM America, Inc.
TH-D7A via Kenwood Communications Corp
Wattmeter via Bird Electronics, Inc

General Prizes:

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ALFA Electronics
ALINCO, Inc.
American Radio Relay League
AMSAT-NA
Andrew Corporation
Arrow Antenna
Bird Electronics, Inc.
Buckmaster
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Winners of the AMSAT Banquet Grand Prizes (from left to right) John Clowe, W4ZPG; Ed Rojowski, N8GZL with Bird Wattmeter; Linda McMillan, KF4SMS: IC-901H; William Reed, WD0ETZ with Kenwood TH-D7; and Linda McMillian, KF4SMS with IC-901H; and Sympoisum Chair Steve Diggs, W4EPI. Note that Linda's home recently burned destroying all of her radio equipment so her IC-901H will come in very handy! (photo by Bruce Paige, KK5DO)

AO-40 discussion panel consisting of (l to r) Stacey Mills, W4SM, Robin Haighton, VE3FRH, Bdale Garbee, KB0G, Paul Wilmott, VP9MU, and Lyle Johnson, KK7P. (photo by Dick Daniels, W4PUJ)

Discussing finer points are (l to r) Randy Kohlwey, N7SFI; Ray Soifer, W2RS; and Harry Yondeda, JA1ANG. (photo by Dick Daniels, W4PUJ)

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[Continued from page 3] This morning at 10:00 local time all church bells in Austria were ringing and everybody was called upon to stop work for five minutes and think of all the victims and pray for them. **Viktor Kudielka, OE1VKW**

Dear Robin and Fellow Radio Amateurs in the US: Here in Copenhagen we have experienced, I think for the first time ever, several thousand people going to the American Embassy to place flowers and candles in respect for the victims. We are all deeply affected. **Ib Christoffersen, OZ1MY, President, AMSAT-OZ**

Same here in Melbourne, many left flowers at the US Consulate. Also, our weekly newscast last night at 1000z included 30 seconds silence as a mark of respect the victims of the terrorist attacks. **Tony Langdon**

Dear Robin: Like other people from over the world, we have been horribly shocked by the events at the World Trade Center in New York and other places in the States. Please be sure that the people of France are very sad of what has happened to their American friends. We send our sincere condolences to our colleagues who may have lost a member of their family. **Bernard Pidoux, F6BVP, President, AMSAT-France**

Dear US Amateurs: Please convey my deepest sympathies to all those people either directly or indirectly affected by the terrible events of the past day in New York, Washington and elsewhere within the USA. 73, **Phil Casper, VK6ZKO, AMSAT 32427**.

Dear All: While viewing with terrible shock from my home, we have been seeing the tragedies in New York. This is to send to all our deep sorrow for this terrible terrorist act with so many American Citizens gone. I hope freedom will come back immediately. Regards, **Nicolaus Sallay, PP8DA**

Dear AMSAT Members: Like Robin our President of AMSAT-NA, I was also shocked and outraged by the attack on America, its citizens, and all those in the World Trade Center, Pentagon and other places too. I have seen the horrors of terrorism for many years but I feel this draws the line and needs to be stopped forever. No human has a right to inflict these terrible acts on innocent people or hold the world hostage.My heart goes out to each and every one of you that is affected by these acts of war and hope that they will feel some comfort in knowing that the rest of the world is supporting you all during these very sad times. The people from Wales send their very sincere wishes of support and condolences to those affected too. **Chris J. Dixon, GW6KZZ**

To the People of America: No words can express the revulsion and horror we feel here in Australia for the act of cowardice that took so many innocent lives. There are no words one can say to make it any better and in fact to try is worse. Also we cannot say we can understand what you are going through because we simply cannot. Please accept that you are in our hearts and our prayers and we think of you constantly. Australia and America have always been very close and we feel your loss keenly. Take care and Stay Well, **Trevor Smith**

Just to let you know that in Mexico we feel very sorry about the terrible incidents that happened on 11SEP01. We are praying for the innocent victims and their families. **Miguel A. Gonzalez, XE2NGT and Family** ■

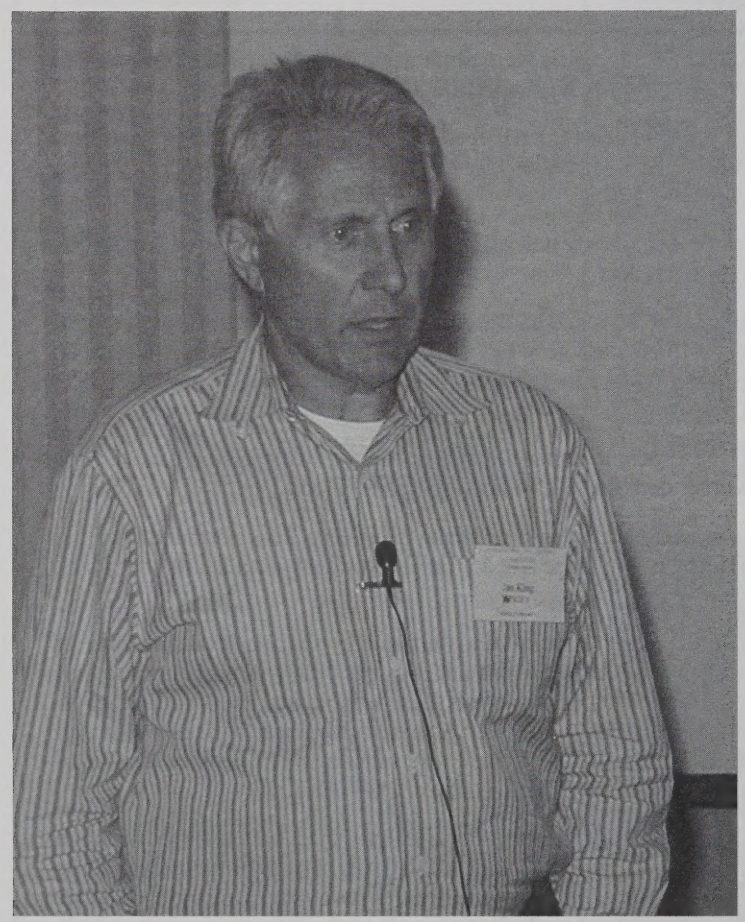
The AMSAT GTO Link Model (Version 2.10)

Jan A. King, W3GEY

I hereby declare this link model to be in the public domain (and available via www.amsat.org). It doesn't contain anything I would not want to tell anyone else. Its purpose is just to teach those who want to learn about link budgets how it may be done. Nothing is secret or proprietary about it (except whatever Bill Gates won't tell us about MS Excel 2000). The contents of this document and the model may be used or reproduced any way anyone wants except you can't sell it and make a profit (that wouldn't be fair now, would it- after I went and gave it away). You can even take it apart and use the pieces if you want to. There is nothing here that isn't in lots of text books, so there is no reason it can't be sent to people from other countries (they probably are better at link analysis than I am anyway). It really doesn't have much to do with satellites either. The transponder in question could just as well be located on a mountaintop. It just happens to be that we want to put it in space so we can talk to one another over greater distances. The link model contains considerable work done by Phil Karn, KA9Q (See ACK at the end). Thanks to him for motivating this work.

Introduction

This link model was developed to assist in the design of an AMSAT-NA follow-on space mission employing a Geostationary Transfer Orbit (GTO). It is intended as an aid to determining the engineering trades between a communications system employing a spinning spacecraft with 1) an antenna that is NADIR at orbit apogee (Jansson mode) vs. 2) a *high gain omni-directional* antenna that is oriented to the orbit NORMAL (Johnson mode). This link model utility also attempts to address the trades that must be made as an all-digital voice/data transponder is incorporated into the spacecraft (Figure 1).



The author, Jan King, W3GEY made a presentation on this model at the Atlanta AMSAT symposium. The model with operating instructions can be obtained via the AMSAT-NA WWW site (*www.amsat.org*). To hear his presentation via Real Audio visit *www.amsatnet.com*. (photo by Dick Daniels, W4PUJ)

Using the Model

First of all, there are some easy ways you can *kill* this set of EXCEL spreadsheets. [I used EXCEL-2000 to develop it.] They are all cross-linked and the cells are not yet protected, since it is still under development. If you are interested in using it, then there are some recommendations I'd make in case you *step* on some cells and erase some of the equations and then you save the entire mess you have created. [I know this because I've done it myself.] So, first save a copy of the file somewhere else (a floppy is a good way to make *more sure* you don't make a mistake). Next, only change the parameters (cells) that have blue text. These cells are intended for user data entry. The black text cells contain equations or cross-links to other spreadsheets. If you do manage to *step on* an equation or cross-linked cell (and you notice it just after hitting the Enter key) the easiest way to recover is to use the UNDO function (that's the L icon on the toolbar). Each time you hit the UNDO icon it will back up one step so, you can even correct multiple mistakes.

There are five worksheets making up the model. The ORBIT PERFORMANCE spreadsheet has some places for data entry for the orbital elements and then a special cell (at B25) that you will be changing quite a lot. The LINK BUDGET worksheet has a data field near the top of the sheet which is the primary method for creating the link model for the mission. The NOISE SUMMARY worksheet is just for looking at. You don't change anything on that one. It provides you with a very fast way of seeing which noise source dominates the uplink and downlink. The SYSTEM LINK SUMMARY worksheet is also just for looking. It provides a summary of the system performance and gives the user a kind of *mini-specification* for each component in the system. The BEAM ROLL-OFF TOOL is just that – a tool. It allows you to enter an antenna size and aperture efficiency and frequency up at the top (again, input into blue cells only) and it shows you what one likely representation of the pattern will be. A Sin (Θ)/Θ representation of the pattern is employed. This same tool is actually used by the LINK BUDGET worksheet for all four antennas completing the link. More on this below.

ORBIT PERFORMANCE Worksheet

I wanted to be able to systematically look at the trades between the spin and antenna modes proposed by Jansson and Johnson (Figure 1). [Not that these gentlemen didn't actually invented anything here but, the names are good shorthand ways of referring to the modes.] I've used the EXCEL version of the INDEX function to allow the communications performance for a given satellite configuration to be evaluated all the way around an elliptical orbit. By loading an integer into [CELL B25] that row of data associated with that CASE number is copied from the row into the LINK BUDGET worksheet. You will see that the cells modified are highlighted with a blue background color in column B of that worksheet. So you move to

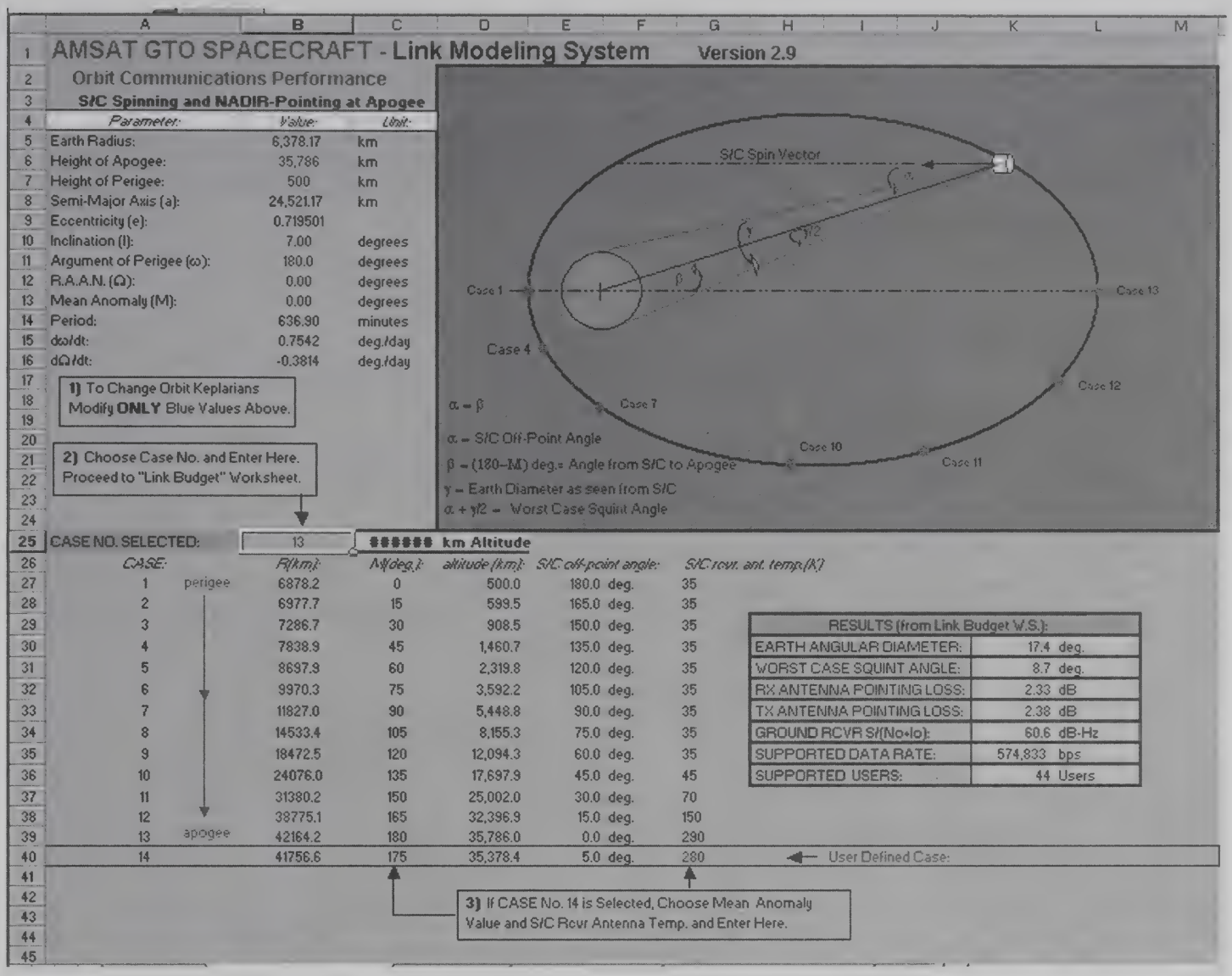

AMSAT GTO SPACECRAFT - Link Modeling System Version 2.9
Orbit Communications Performance
S/C Spinning and NADIR-Pointing at Apogee
Parameter: Value: Unit:
Earth Radius: 6,378.17 km
Height of Apogee: 35,786 km
Height of Perigee: 500 km
Semi-Major Axis (a): 24,521.17 km
Eccentricity (e): 0.719501
Inclination (I): 7.00 degrees
Argument of Perigee (ω): 180.0 degrees
R.A.A.N. (Ω): 0.00 degrees
Mean Anomaly (M): 0.00 degrees
Period: 636.90 minutes
dω/dt: 0.7542 deg./day
dΩ/dt: -0.3814 deg./day
1) To Change Orbit Keplarians Modify ONLY Blue Values Above.
2) Choose Case No. and Enter Here. Proceed to "Link Budget" Worksheet.
S/C Spin Vector
Case 1
Case 4
Case 7
Case 10
Case 11
Case 12
Case 13
α = β
α = S/C Off-Point Angle
β = (180–M) deg.= Angle from S/C to Apogee
γ = Earth Diameter as seen from S/C
α + γ/2 = Worst Case Squint Angle
CASE NO. SELECTED: 13 ###### km Altitude
CASE: R(km): M(deg.): altitude (km): S/C off-point angle: S/C rcvr. ant. temp.(K)
1 perigee 6878.2 0 500.0 180.0 deg. 35
2 6977.7 15 599.5 165.0 deg. 35
3 7286.7 30 908.5 150.0 deg. 35
4 7838.9 45 1,460.7 135.0 deg. 35
5 8697.9 60 2,319.8 120.0 deg. 35
6 9970.3 75 3,592.2 105.0 deg. 35
7 11827.0 90 5,448.8 90.0 deg. 35
8 14533.4 105 8,155.3 75.0 deg. 35
9 18472.5 120 12,094.3 60.0 deg. 35
10 24076.0 135 17,697.9 45.0 deg. 45
11 31380.2 150 25,002.0 30.0 deg. 70
12 38775.1 165 32,396.9 15.0 deg. 150
13 apogee 42164.2 180 35,786.0 0.0 deg. 290
14 41756.6 175 35,378.4 5.0 deg. 280 User Defined Case:
RESULTS (from Link Budget W.S.):
EARTH ANGULAR DIAMETER: 17.4 deg.
WORST CASE SQUINT ANGLE: 8.7 deg.
RX ANTENNA POINTING LOSS: 2.33 dB
TX ANTENNA POINTING LOSS: 2.38 dB
GROUND RCVR S/(No+Io): 60.6 dB-Hz
SUPPORTED DATA RATE: 574,833 bps
SUPPORTED USERS: 44 Users
3) If CASE No. 14 is Selected, Choose Mean Anomaly Value and S/C Rcvr Antenna Temp. and Enter Here.

Figure 1. Orbit Communications Functions

B25, insert and integer and hit return. You will find the altitude associated with the selected case displayed to the left at [**CELL C25**]. The important results of the entire LINK BUDGET worksheet are then displayed in yellow/orange to the right of the data table at the bottom of the worksheet. These results are dynamically linked to the LINK BUDGET worksheet. A last case, CASE 14, provides for a user-defined position in the orbit. If you don't like the 15-degree steps in mean anomaly that I have selected, you can manually enter your own but, you must provide the data called for in blue within that row. Three **NOTES** located within the worksheet prompt you as to how to use this worksheet.

The value of using this approach is you can very quickly see the performance of the system as the spacecraft moves around the orbit. The model assumes, right now, that the satellite is spinning and NADIR pointing (earth centered) at apogee. The attitude (i.e. spin vector) remains the same around the orbit. The performance is always predicted at the *worst-case* squint angle position. That's the position that has the largest angle between the S/C antenna boresight and the user on the Earth. Later, after everyone has used with the model, I'll change the antenna model on the spacecraft to be a *high gain* omni. Then we can run this around the orbit to see how the Johnson design does. The game here is to play with the antenna gains at the spacecraft (uplink and downlink) to establish the best trade between users capacity at apogee and a minimum change in user capacity as the satellite moves away from apogee. The current values for the antennas in the model probably have too much gain. See if you agree.

LINK BUDGET Worksheet

A lot of this particular worksheet was created by Phil Karn, KA9Q (Figures 2a and 2b). He is interested in investigating the performance of an all-digital system. He started with a time division multiple access (TDMA) type of system. In such a system each user takes a slice of time and occupies the entire transponder passband with a single data burst. The burst is at the full data rate supported by the system. Even though the user is most interested in only 13 kbps of the downlink stream, he gets it all. He may choose to discard all but his QSO's 13 kbps or not.

The spreadsheet is organized so that the user may enter the key system parameters into the blue cells at the top of the worksheet. The bottom half of the worksheet does the calculations that follow a signal and the noise that *attends* it, all the way through the sys-

	A	B	C	D	E	F	G	H
1	AMSAT GTO SPACECRAFT							
2	Spreadsheet for Computing Link Budgets with a Bent-Pipe Satellite Transponder							
3	2001, September 7							
4	Original: Phil Karn, KA9Q	Blue	= User Data Entry Values			Red	= Key Results	
5	Additions: Jan A. King, W3GEY	Black	= Computed Values (No Data Entry)			NOTE: Cells Not Yet Protected		
6	Version 2.3							
7								
8	Parameter:	Value:	Unit:	Comment(s):				
9	*Orbit values:*							
10	earth radius	6378.2	km					
11	current spacecraft altitude	35,786	km	inserted from Orbit Performance W.S.				
12	max. slant range (ground station-to-spacecraft)	41,679	km	max. slant range value				
13	earth angular diameter as seen at spacecraft	17.4	deg.					
14	*User Input Values:*							
15	*Uplink path:*							
16	uplink frequency	1260.0	MHz	uplink wavelength	m	0.24		
17	ground transmit power	50.0	W					
18	ground station line losses + misc. losses	0.5	dB					
19	ground transmitter HPA intermod. Ratio (IMR)	11.0	dB	slightly backed-off HPA				
20	ground transmit antenna diameter	0.75	m					
21	ground transmit antenna aperture efficiency	65%						
22	ground transmit antenna pointing error	1.5	deg.					
23	uplink polarization loss	0.25	dB					
24	uplink atmospheric+ionospheric losses	1.1	dB	At 10 deg. min. elevation angle				
25	*Spacecraft:*							
26	spacecraft off-point angle from the center of the ea	0.00	deg.	inserted from Orbit Performance W.S.				
27	spacecraft receive antenna diameter	0.85	m					
28	spacecraft receive antenna aperture efficiency	55%						
29	spacecraft receive line losses + misc. losses	1.0	dB					
30	spacecraft receive antenna effective noise temperature	290.0	K	inserted from Orbit Performance W.S.				
31	spacecraft effective line loss temperature	275.0	K	estimated S/C mean temp.				
32	spacecraft LNA temperature	90.0	K					
33	spacecraft power out	50.0	W					
34	spacecraft transmit line + misc. losses	0.75	dB					
35	spacecraft transponder intermodulation ratio (IMR)	11.0	dB	slightly backed-off HPA				
36	spacecraft transponder DC/RF Efficiency	0.4						
37	spacecraft transponder bandwidth	#####	Hz					
38	downlink frequency	2401.0	MHz	downlink wavelength	m	0.12		
39	spacecraft transmit antenna diameter	0.45	m					
40	spacecraft tranmsit antenna aperture efficiency	55%						
41	*Downlink path:*							
42	downlink polarizaton loss	0.25	dB					
43	downlink atmospheric+ionospheric losses	1.2	dB					
44	ground receive antenna diameter	0.75	m					
45	ground receive antenna aperture efficiency	65%						
46	ground receive antenna pointing error	1.5	deg.					
47	ground receive line + misc. losses	0.5	dB					
48	ground receive antenna noise temperature (sky temp	35.0	K					
49	ground receive equipment temperature	290.0	K					
50	ground receive system LNA noise temp	85.0	K					
51	required digital Eb/No or analog SNR	3.0	dB	to achieve 10E-6 b.e.r. w coding				
52	per user digital data rate or analog bandwidth	13000	bps or Hz	1.0 bps/Hz = peak rate-to-B.W.				
53	*Computed Values:*							
54	*Uplink path:*							
55	ground transmit power	17.0	dBW					
56	ground transmit antenna gain	18.0	dBi					
57	ground transmit antenna beamwidth (-3dB)	22.2	deg.					
58	ground transmit antenna pointing loss	0.05	dB	Based on Sin X/ X Roll-Off of Beam		10.77	*Intermediate Result (Ignore)*	
59	ground transmit EIRP	34.5	dBW					

Figure 2a. Spreadsheet for Computing Link Budget with a Bent-Pipe Satellite Transponder (continued).

tem (from transmitter, to uplink path, to spacecraft, to downlink path and then to the receiver). A few comment on some of the parameter names and functions used:

- At the top, don't change anything in the Orbit Values section.
- Start changing things, if you like, at [CELL B16]. The way you change an antenna is to enter its diameter (pretend it's a dish even if it's a Yagi or helix with the equivalent aperture size) and aperture efficiency. If you don't know too much about the antenna you might like, pick an aperture efficiency around 50 to 55%. If you want to see what the pattern of that antenna would look like, go to the last worksheet: BEAM ROLL-OFF TOOL. Enter the same data there and look at either the table or the plot to see what a worst case pattern would be like. [NOTE: The sidelobe structure assumed is not highly optimized but, is about typical for many kinds of antennas.]
- Don't change [CELL B26] or [CELL B30].
- The transponder bandwidth at [CELL B37] has to be wide enough to accommodate the symbol rate computed at [CELL B103]. Assume

	A	B	C	D	E	F	G	H
57	ground transmit antenna beamwidth (-3dB)	22.2	deg.					
58	ground transmit antenna pointing loss	0.05	dB	Based on Sin X/ X Roll-Off of Beam		10.77	Intermediate Result (ignore)	
59	ground transmit EIRP	34.5	dBW					
60	uplink path loss	186.9	dB					
61	*Spacecraft:*							
62	spacecraft receive antenna gain	18.4	dBi					
63	spacecraft receive antenna beamwidth (-3dB)	19.6	deg.					
64	spacecraft worst case squint angle to ground statio	8.7	deg.					
65	spacecraft receive antenna pointing loss	2.33	dB	Based on Sin X/ X Roll-Off of Beam		70.78	Intermediate Result (ignore)	
66	spacecraft transmission line coefficient	0.794						
67	spacecraft receive system noise temperature	377	K					
68	spacecraft receive signal power	-138.6	dBW					
69	spacecraft receive noise density	-202.8	dBW/Hz					
70	spacecraft receive I/M power density from Gnd. Stn	-212.7	dBW/Hz					
71	spacecraft receive (No+Io)	-202.4	dBW/Hz					
72	spacecraft receive S/(No+Io)	63.8	dB-Hz					
73	spacecraft transponder gain	153.0	dB					
74	spacecraft transmit repeated noise density	-49.4	dBW/Hz					
75	spacecraft transmit S/(N+I) at xpdr output	0.7	dB	In full transponder bandwidth				
76	noise power loss	3.0	dB					
77	spacecraft transponded signal power	25.2	Watts					
78	spacecraft transponded uplink total noise power	21.2	Watts					
79	spacecraft transponded intermodulation power	3.7	Watts					
80	spacecraft transponder required DC input power	125.0	Watts					
81	spacecraft tranmsit antenna gain	18.5	dBi					
82	spacecraft transmit antenna beamwidth	19.4	deg.					
83	spacecraft transmit antenna pointing loss	2.38	dB	Based on Sin X/ X Roll-Off of Beam		71.41	Intermediate Result (ignore)	
84	spacecraft transmit signal EIRP	29.36	dBW					
85	spacecraft transmit noise EIRP density	-32.95	dBW/Hz					
86	*Downlink path:*							
87	downlink path loss	192.5	dB					
88	ground receive antenna gain	23.6	dBi					
89	ground receive antenna beamwidth (-3dB)	11.7	deg.					
90	ground receive antenna pointing loss	0.19	dB	Based on Sin X/ X Roll-Off of Beam		20.52	Intermediate Result (ignore)	
91	ground receive signal power	-140.4	dBW					
92	ground receive system transmission line coefficient	0.891						
93	ground receive system noise temperature	147.7	K					
94	ground receive repeated noise power density	-202.3	dBW/Hz	equivalent temp	K	430.4		
95	ground receive thermal noise density	-206.9	dBW/Hz	equivalent temp	K	147.7		
96	ground receive total noise density (No+Io)	-201.0	dBW/Hz	equivalent temp	K	578.1		
97	ground receive S/(No+Io)	60.6	dB-Hz					
98	ground receive noise power	-138.0	dBW	In Full Xpdr Bandwidth				
99	ground receive S/N	-2.41	dB	In Full Xpdr Bandwidth				
100	supported data rate	#####	bps					
101	ground receive S/N in data rate bandwidth	3.0	dB	held constant				
102	ground receiver aggregate code rate	0.4		block + convolutional coding				
103	symbol rate	#####	sps					
104	number of supported users	44		with no protocol overhead				
105								
106	single-user margin	16.5	dB					
107								
108	loss relative to regeneration	8.9	dB					

Figure 2b. Spreadsheet for Computing Link Budget with a Bent-Pipe Satellite Transponder (concluded).

about 1 symbol/Hz to go between the two. If you're not sure about all this you might want to leave the bandwidth at about 2 MHz.

- The uplink and downlink *atmospheric + ionospheric loss* values are from a book by L. Ippolito (NASA) and are set for a typical (not worst case) atmosphere and at an elevation angle of 10°. This is NOT entirely consistent with the squint angle determination which is for a worst case user (who is at 0° elevation angle). I was afraid to use the losses associated with 0° (too high and unrealistic- Ippolito says it's greater than 10 dB) and I didn't want to do the math to determine the squint angle for 10°. So there is a small error here. Feel free to fix it if you have the time.
- The polarization loss has to do with the axial ratio (ellipticity) of the two antennas associated with each link. If people want to play with this parameter, I have a little software module available which I can add (or just send you). It takes the axial ratio of the two antennas and the angle between the major axis of the two ellipses created and computes the loss you can expect. Ask, and I shall forward it.
- If one wants to do these links correctly you need to know the noise temperatures for the receiver pretty well. The antenna temperature (some call it the sky temperature), the physical temperature of the feed lines and, of course, the LNA temperature are important to know. Tom Clark, W3IWI has provided noise values that have been added to the spreadsheet. Remember though, we assume that we are designing the user terminal in this system (unique for AMSAT, but not the rest of the world) so the value we pick for LNA temperature and feedline loss should be as for a manufactured item, not what the best radio amateur could make in his shack with all the time in the world to *tweak* the amplifier. Other than that,

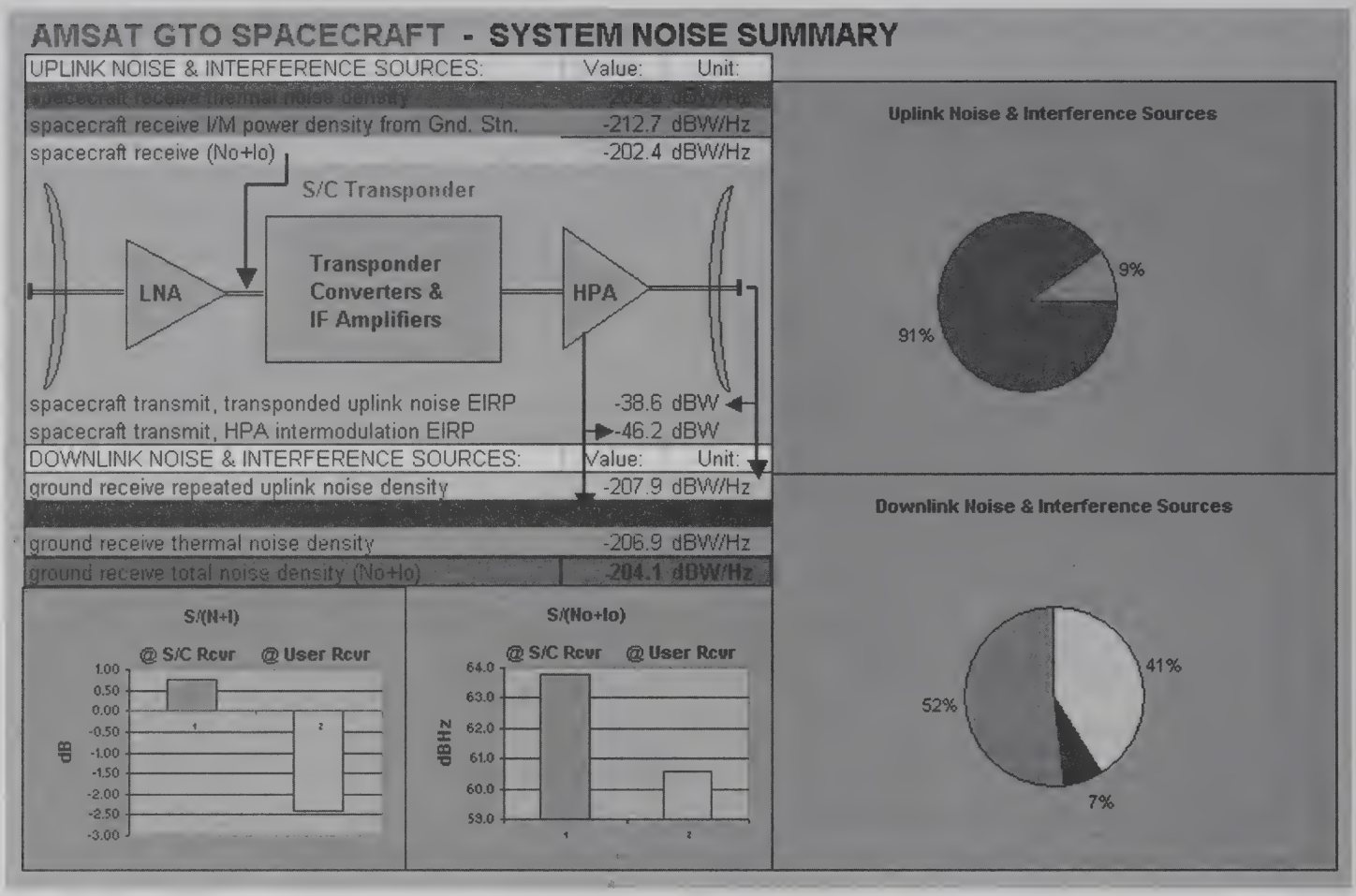


Figure 3. System Noise Summary

assume away!

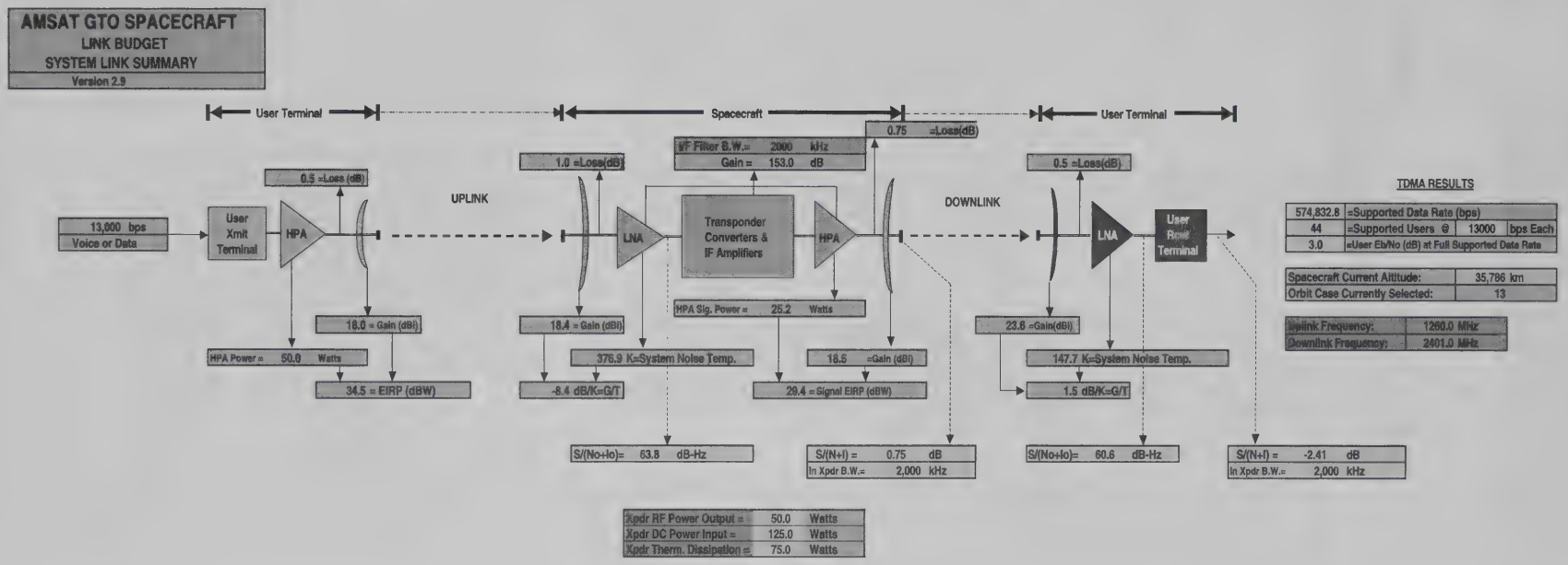
- An important note: There are two approaches that can be taken to a link model of this type as signals flow through the system. One can use powers (dbm or dBW) or densities (dBW/Hz). Phil chose to use densities. This may be a less familiar way to go from many radio amateurs. Remember, the computation of S/N is in power. The parameter S/No here is a sort of mixed unit. It's a power (dBW) divided by a power density (dBW/Hz) which results in the units being in Hz (actually dBHz). The way to think about this parameter is that S/No is the signal to noise ratio in a 1 Hz bandwidth. Now, if you subtract 10*log(Bit Rate) from S/No you obtain the S/N of your signal at the Bit Rate you have picked. This is pretty much the same as the ever-popular Eb/No parameter, by the way. Very useful. So, we carry signals and noise through the system as *densities*, not as *powers*. [You have to start to think like this – kinda like driving on the left side of the road.] The parameter "Io" [or, you will see it expressed in a relationship like S/(No+Io)] is also a density. It is the power density for a particular interference source (like intermod) or it is the power density of the sum of all interference terms.

- Because it is probably more familiar to you (and to me), I have also added good ol' S/N values to the worksheet. It is computed at two places: once at the spacecraft receiver and again at the ground station receiver (this one is **THE S/N** for the system). These are true power ratios, not densities. The thermal noise power is computed based on the bandwidth selected at [CELL B37]. You will notice that the final S/N value for many cases is negative. Don't fret about this. It's not that uncommon. Remember you have all the noise for the full bandwidth of the transponder against which to compare the signal. Somewhere in the ground receiver you will improve S/N by using a filter approximately matched to the signal bandwidth. Then S/N will be *all better* again. As the system performance gets poorer (say you reduce the uplink EIRP) the link model will start ratcheting down the data rate of the system. When this occurs, it may well be a good idea to narrow the transponder bandwidth parameter as there is little value in wasting precious spacecraft RF power transmitting noise. The transponder bandwidth parameter should be a little wider than the *symbol rate* parameter located at [CELL B103].

NOISE SUMMARY Worksheet

The NOISE SUMMARY worksheet is not modified by the user (Figure 3). It is a way of quickly viewing the results of the system, particularly with regard to the balance of noise and interference power within the system. The left hand columns of the worksheet tabulate the noise densities (first, for the uplink and then for the downlink). Colors are important for the pie charts. The background color of the density entries on the left match the pie chart colors.

The upper pie chart shows the percentage


AMSAT GTO SPACECRAFT
LINK BUDGET
SYSTEM LINK SUMMARY
Version 2.9
User Terminal
Spacecraft
User Terminal
0.75 =Loss(dB)
IF Filter B.W.= 2000 kHz
Gain = 153.0 dB
1.0 =Loss(dB)
0.5 =Loss (dB)
0.5 =Loss(dB)
UPLINK
DOWNLINK
13,000 bps
Voice or Data
User Xmit Terminal
HPA
LNA
Transponder Converters & IF Amplifiers
HPA
LNA
User Rcv Terminal
18.0 = Gain (dBi)
18.4 = Gain (dBi)
HPA Sig. Power = 25.2 Watts
23.6 =Gain(dBi)
HPA Power = 50.0 Watts
376.9 K=System Noise Temp.
18.5 =Gain (dBi)
147.7 K=System Noise Temp.
34.5 = EIRP (dBW)
-8.4 dB/K=G/T
29.4 = Signal EIRP (dBW)
1.5 dB/K=G/T
S/(No+Io)= 63.8 dB-Hz
S/(N+I) = 0.75 dB
In Xpdr B.W.= 2,000 kHz
S/(No+Io)= 60.6 dB-Hz
S/(N+I) = -2.41 dB
In Xpdr B.W.= 2,000 kHz
Xpdr RF Power Output = 50.0 Watts
Xpdr DC Power Input = 125.0 Watts
Xpdr Therm. Dissipation = 75.0 Watts
TDMA RESULTS
574,832.8 =Supported Data Rate (bps)
44 =Supported Users @ 13000 bps Each
3.0 =User Eb/No (dB) at Full Supported Data Rate
Spacecraft Current Altitude: 35,786 km
Orbit Case Currently Selected: 13
Uplink Frequency: 1260.0 MHz
Downlink Frequency: 2401.0 MHz

	A	B	C	D	E	F	G	H	I	J	K
1	**Antenna Beam Roll-Off Tool**										
2	**Sidelobe Positions Based on Sin X/ X Formulation**								J. A. King 8/13/2001		
3											
4	**Frequency:**	1.26	GHz		**Peak Gain:**	18.4	dBi				
5	**Antenna Dia.:**	0.85	Meters								
6	**Aperture Efficiency:**	55	%		**P/2 Beamwidth:**	19.61	Degrees	=2θ (@ -3dB Roll-off)			
7											
8						**Pwr (θ) w.r.t. Peak Gain:**			**θ (degrees):**		
9		0.0001	0.000305	304.6174	1.000000	**0**	**dB**		**0.0000**	*Main Lobe*	
10		0.1	0.000305	304.6171	0.99999905	**0**	**dB**		**0.012**		
11		3.5	0.000304	304.2387	0.998756829	**-0.01**	**dB**		**0.430**		
12		10	0.000302	301.5369	0.989887301	**-0.04**	**dB**		**1.2**		
13		25	0.000286	285.7699	0.938127344	**-0.3**	**dB**		**3.1**		
14		30	0.000278	277.7778	0.911890712	**-0.4**	**dB**		**3.7**		
15		40	0.000258	258.2349	0.847735371	**-0.7**	**dB**		**4.9**		
16		47	0.000242	242.1359	0.794885372	**-1.00**	**dB**		**5.8**		
17		56.5	0.000218	217.8293	0.715091436	**-1.5**	**dB**		**6.9**		
18		60	0.000208	208.3333	0.683918034	**-1.6**	**dB**		**7.4**		
19		70	0.00018	180.2086	0.591590029	**-2.3**	**dB**		**8.6**		
20		79.76	0.000152	152.224	0.499722061	**-3.01**	**dB**		**9.6**	*(Half Power B.W.)/2*	
21		80	0.000152	151.5385	0.497471536	**-3.03**	**dB**		**9.8**		
22		90.8	0.000121	121.2673	0.398097019	**-4.00**	**dB**		**11.16**		
23		100	9.7E-05	96.98463	0.318381783	**-5.0**	**dB**		**12.3**		
24		110	7.3E-05	72.97704	0.239569516	**-6.2**	**dB**		**13.5**		
25		120	5.21E-05	52.08333	0.170979509	**-7.7**	**dB**		**14.8**		
26		130	3.47E-05	34.72332	0.113989939	**-9.4**	**dB**		**16.0**		
27		140	2.11E-05	21.0804	0.069202887	**-11.6**	**dB**		**17.2**		
28		150	1.11E-05	11.11111	0.036475628	**-14.4**	**dB**		**18.4**		
29		160	4.57E-06	4.569444	0.015000602	**-18.2**	**dB**		**19.7**		
30		170	1.04E-06	1.04338	0.003425216	**-24.7**	**dB**		**20.9**		
31		180	4.63E-37	4.63E-31	1.52082E-33	**-328.2**	**dB**		**22.1**	First Null	
32		190	8.35E-07	0.835282	0.00274207	**-25.6**	**dB**		**23.4**		
33		200	2.92E-06	2.924444	0.009600385	**-20.2**	**dB**		**24.6**		
34		210	5.67E-06	5.668934	0.018610015	**-17.3**	**dB**		**25.8**		

Figure 5. Beam Roll-off Tool

of power density associated with white noise (called more formally, thermal noise) generated on the uplink (red) and the percentage of power density that is from the intermodulation junk generated by the user uplinking transmitter (green). Here's an interesting experiment. Increase the user uplink antenna gain with the spacecraft at apogee. Don't change anything else. You will notice the thermal noise percentage goes down but, the intermodultion percentage goes up as it must. This is correct.

The lower pie chart is a bit more significant. It shows the percentage of the noise density that is all the junk (uplink white noise + user transmitter intermod.) transponded by the spacecraft (that's in yellow), the percentage of the noise density that is ground receiver white noise (orange) and the noise density that is from intermodulation products generated at the spacecraft. This pie chart is kind of the noise power *bottom line*.

The left bar chart at the bottom shows the S/N [really the S/(N+I)] first on the uplink and then at the user's receiver. [Remember, this is the ratio of powers – dimensionless parameter. It's taken at the full bandwidth of the transponder.] The right bar chart is the S/(No+Io) parameter at the spacecraft and at the user's receiver. [Remember, this is the value with the mixed units that is going to tell you how much data you can really transmit through the system].

All the charts are auto-scaling so you don't have to worry about changing anything on the worksheet. I think you will find this worksheet quite useful once you learn to use the model.

SYSTEM LINK SUMMARY Worksheet

This worksheet is my way of summing up the results of the system for those who may not be that familiar with link analysis (Figure 4). It's obviously a little block diagram of the system. The *results* boxes are all dynamically linked to the earlier spreadsheets. So, you can wander through the system and see what you have created and what the results of it are.

The system parameters that have been chosen are summarized in the blue boxes located around the block diagram. The yellow boxes show intermediate results at various points within the system. The teal colored boxes at the bottom summarize the spacecraft power utilization and dissipation requirements. Finally, the boxes to the far right (various colors) summarize the final outcome of the system and summarize the orbit and frequency choices made by the model operator.

BEAM ROLL-OFF TOOL Worksheet

This tool is a bit crude and I will eventually clean it up a little (Figure 5). But, if you enter the parameters for the antenna you wish to investigate into [CELLS B4, B5 and B6] then

the peak gain and -3dB beamwidth are calculated at [CELLS F4 and F6]. Now look at columns F and I starting at F9 and I9. Ignore the columns to the left. Here you will find how the antenna rolls off as a function of angle from boresight. There is also a plot of the pattern to the right and down a ways in the worksheet. This plot is set up so that it auto-scales. The pattern is based on a Sin (Θ)/Θ relationship between gain and angle. Actually, when someone tells you they are using this representation, they are really talking about the voltage envelope of the signal in relation to the angle Θ. But, we want to know what *power* does vs. Θ. Since power is proportional to the square of voltage, the relationship we really want is: $P(\Theta) = A*\mathrm{Sin}^2(\Theta)/\Theta^2$. That's the function which has been employed here. Note the value of Θ at the –3dB roll-off point is equal to ½ of the *half power beamwidth* because you are only observing ½ of the pattern.

You may well say, "Gee, that first sidelobe looks terrible: only –13 dB!" Well true, this is not what a high technology offset fed parabola with an optimized taper will give you. But, it may be a good model since we don't know whether we are using dishes or yagis or helicies or whatever(?) within our system. So, I maintain that a crummy first sidelobe-producing antenna like this is a good first approximation for what our system radiators may look like. Also, if you don't like this you may wish to develop a better closed form relationship we can plug into the model. NOTE: The BEAM ROLL-OFF Worksheet is not cross-linked to the other spreadsheets. It's just a tool you can use to play with an antenna design.

Acknowledgements

The primary link budget you see in the LINK BUDGET worksheet was originally developed by Phil Karn, KA9Q. It's a bit different than the way I would have developed it but, it's a very good way. He put the user entry data at the top of the worksheet and the calculations at the bottom. The important thing is that the order in which the entries occur should be the way they occur as you pass from the beginning to the end of the link. Otherwise things get very confusing if you haven't done this before.

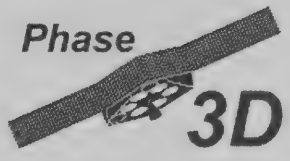
He also decided to flow *power density* values through the link, not *power* values. Both methods work fine. For digital systems and when complex interference terms are involved, the power density approach is the way to go. He developed the link budget as a means of evaluating TDMA modes of sharing a hard limiting transponder. I reviewed, edited and modified (mostly added to) this spreadsheet. The other worksheets are my creation. The model was briefly reviewed by Franklin Antonio, N6NKF. Thanks to both of them for assisting and for some of the inspiration necessary to actually finish this up.

In Conclusion

Have fun playing with this. Help us all find the bugs and give me lots of feedback. I hope we can improve and fine-tune this model as we go forward. We can change the model as Phil and others determine the best digital multiple access scheme for the digital transponder. This model can also be adapted for a linear FDMA (traditional AMSAT) transponder as needed. Changes to the antennas used and improved attitude models may also be incorporated. This should get us going and thinking, I hope.

73, Jan, W3GEY, 760-781-1728, w3gey@amsat.org, 1136 Rosehill Ct., Escondido, CA 92025 ■

Tracking AO-40?



AMSAT-NA has reduced the cost of the popular Kansas City Tracker/Tuner by $50!

The Kansas City Tracker is a hardware and software package which enables an IBM compatible computer (with spare ISA slot) to connect to an antenna rotor controller, in order to perform automated elevation and azimuth positioning and satellite tracking. **The Kansas City Tuner** option provides automatic Doppler shift compensation for digital satellite operation. It automatically adjusts the radios transmit and receive frequencies during a satellite pass. ***And now the price has been reduced to $269.00 plus shipping ($5 U.S./ $20 foreign).***

...also with each KCT unit sold *AMSAT* will include *free* the latest version of *InstantTrack !*

AMSAT-NA 850 Sligo Avenue, Suite 600, Silver Spring, MD 20910-4703 Telephone: 301-589-6062

PCsat in Orbit!

Bob Bruninga, WB4APR

PCsat was launched at 0240 UTC on 30 September 2001 from the Kodiak Alaska Launch Complex as an auxiliary payload on the Kodiak Star mission. PCsat is an amateur satellite developed by students at the US Naval Academy with the mission of providing mobile and handheld satellite AX.25 packet digital communications (Figures 1 and 2). Since being placed into orbit, PCsat has been demonstrating its capability to perform mobile vehicle tracking and communications for APRS/GPS equipped remote travelers that are far from any existing APRS terrestrial tracking infrastructure. PCsat's downlink from such users is being fed into the existing worldwide Internet-linked APRS system by several volunteer ground stations. For those remote areas of the world where there are no APRS Internet gateways, PCsat also has a limited Emergency Status and Reporting Capability.

Constructed as a US Naval Academy aerospace student project, PCsat has given students real hands-on experience in designing and operating a satellite. The project was funded by the US Naval Academy and a grant from Boeing Corporation and launch was secured through the DoD's Space Test Program in cooperation with NASA. PCsat is a unique approach to amateur satellite design by simply using off-the-shelf transmitters and receivers interfaced to an AX.25 TNC and having no other control system on board. The TNC provides the communications payload, the telemetry packets and the command functions using the features that are built in to the Kantronics Plus series of TNC.s

In this case, PCsat consists of two identical systems called the "A" side and "B" side. Both downlink on 2 meters and each has both a VHF and UHF uplink receiver. The "A" side is the public side for use worldwide, while the B side is reserved for downlink over the North American Continent on the existing terrestrial APRS frequency. The following frequencies are used by PCsat:

- 145.825 MHz: 1200 baud downlink (Handheld and low-power stations)
- 145.825 MHz: 9600 baud downlink (Telemetry, mobiles, and high powered stations)
- 144.390 MHz: 1200 baud downlink over the United States for brief PCsat position and telemetry

Figure 3 shows the first four orbits of PCsat beginning with separation (SEP) off the coast of Somalia approximately 70 minutes after launch. Early reports of PCsat's signal were reported from stations in Alaska, Hawaii, South Africa, and the SANAE station in Antarctica. Within 12-hours after launch, PCsat's signals were reported being heard throughout the world.

Figure 1. A team of US Naval Academy students were involved in constructing PCsat.

PCsat was activated for APRS users at 1930UTC on 03 October 2001 and was successfully demonstrated to participants of the 19th AMSAT Annual Meeting and Space Symposium in Atlanta, Georgia (see page 1). Using a Kenwood TH-D7 in the parking lot of the Holiday Inn Select, WB4APR and other symposium participants were able to successfully demonstrate the exchange of APRS packets with PCsat. Since activation, a PCSsat user service agreement has been prepared as a guide for using PCsat (Figure 4).

Since the Atlanta demonstration PCsat has sometimes been resetting randomly causing it to lose some of its setup parameters. To avoid any frustration to users and until we figure out what is going on, we changed our recommended operating procedures so that NORMAL user mode and RESET mode are the same (Figure 5). Thus, you will not have to change parameters if it happens to RESET prior to your pass.

We took this step because PCsat appears to be safe, with a good power budget and not in any danger (Figure 4). So users are authorized to digipeat via the "A" side CALLSIGNs of W3ADO-1 or W3ADO-2 in accordance with the recommended procedures posted on the satellite bulletins and WWW page. We will not be reloading it with the normal PCSAT-1 and -2 calls for now which were the intended callsigns.

PCsat Emergency Status and Reporting (SAR) Capability

A unique feature of PCsat is a limited Emergency Status and Reporting (SAR) capability to assure that emergency and priority packets from travelers anywhere on Earth can be captured and not just those in range of an Internet gateway downlink station.

This SAR mission is necessary as a separate function because the mission of PCsat is to relay all packets back to the Earth in real time. This normal mode of PCsat assumes that there are other users or Internet gateways in the footprint. This leaves travelers in the middle of the oceans or at the poles without communications capability.

As a result, we asked Kantornics to modify the normal TNC heard log so that it will capture EMERGENCY messages from users anywhere on Earth and will downlink the last N packets in this buffer once every 10 minutes. There is the ability to also use this buffer for very special travelers that may need non-emergency access in far away

places. Since this takes extra power and adds to the downlink everywhere, we want to limit this capability to only those wilderness or distant PCsat users who have no other means to communicate. So far, this function has not been activated.

If there are any distant travelers or special events that need this service, we ask that planners register with us in advance of your travels and to send us a travel plan and we will give you the details of this system.

Future Satellite Concepts

As I announced at the AMSAT Symposium in Atlanta, the Naval Academy has possibly more launch opportunities next year. We are committed to putting TNC digipeaters just like PCsat on board each future mission. However we would like to add an additional PSK-31 experiment to our next communications payload.

What I solicited at the AMSAT Symposium was that I would also like to fly a 10m SSB receiver that could be switched into the 2m FM downlink. Thus, 2.4 kHz or so of analog uplinks can be transmitted back down with no Doppler on the FM downlink. The most efficient way to use this narrow bandwidth among the largest number of users is to use PSK-31 which can handle as many at 30 or so users in this bandwidth.

Figure 2. A prototype of PCsat. Two additional launch opportunities exist for this technology. Visit www.amsatnet.com to hear WB4APR's PCsat presentation.

Anyone with a 2m FM rig and a sound card could copy these dozens of simultaneous PSK-31 uplinks. And because the FM downlink preserves exactly the spacing and position of each uplink relative to a pilot tone without any Doppler, then everyone can account for their own uplink Doppler independent of what the satellite or other users are doing.

All we need is to build the XTAL controlled single frequency 10m SSB receiver with high

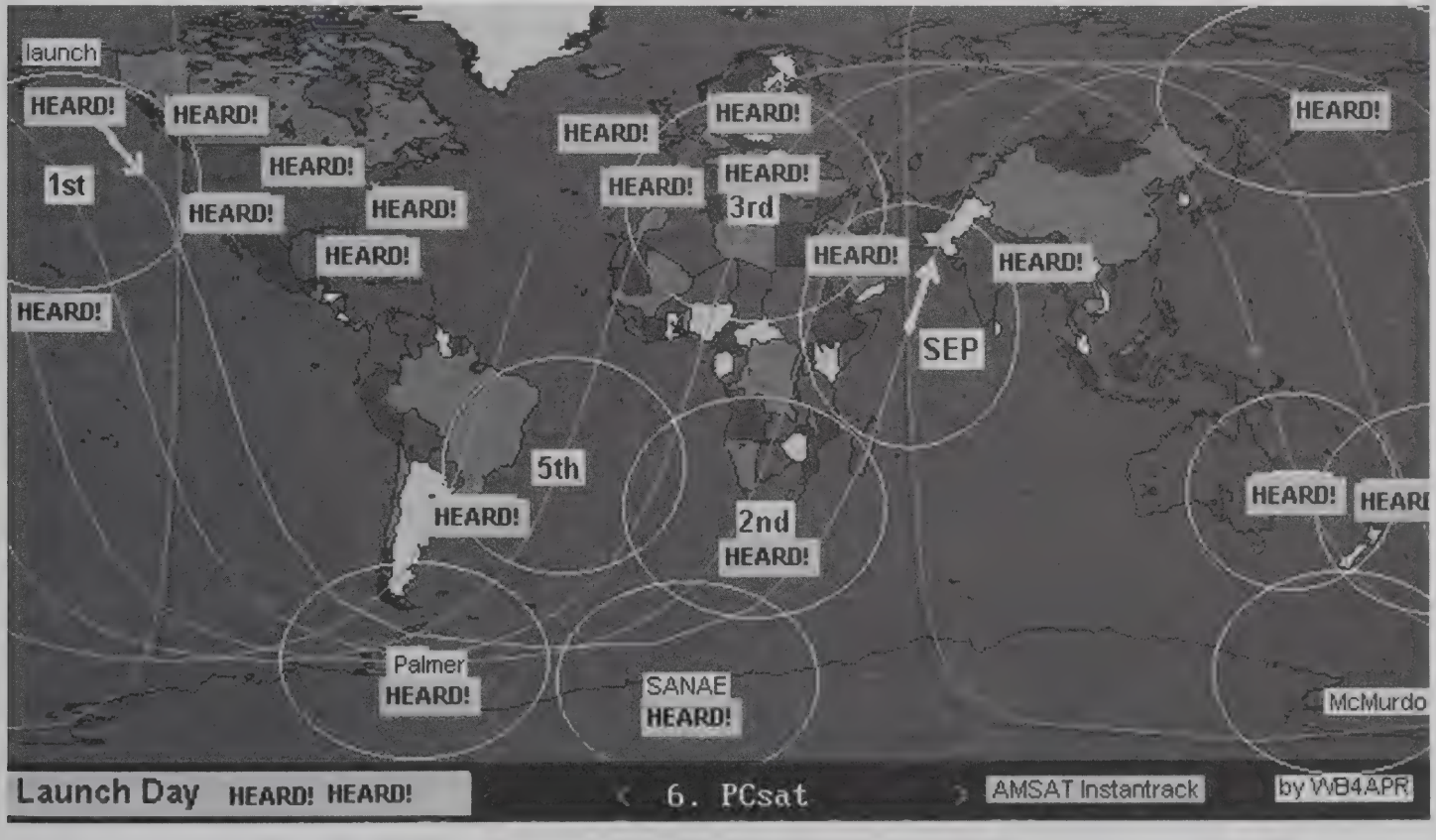


Figure 3. PCSAT's first four orbits and submitted telemetry reports.

SERVICE: PCsat provides a worldwide position, status and messaging service for mobile and handheld amateur radio satellite users. Base station transmissions through PCsat are not encouraged except for special tests, demos or other circumstances. Grade of service depends on user adherence to Power levels, transmission Period, and Precedence criteria.

POLICY STATEMENT: PCsat is an open system in accordance with the ITU regulations for the Amateur Satellite Service. To provide the best overall throughput for the largest collection of users PCsat is protocol driven and requires that all users adhere to the fundamental protocol requirements at all times. Users that adhere to these published protocol and operating standards are welcome.

AGREEMENTS: You may use PCsat if you adhere to the following agreements:

1. Keep informed of the current protocol requirements via the PCsat WWW page (*http://www.ew.usna.edu/~bruninga/pcsat.html* and/or via bulletins in the downlink. As of activation on 03 October 2001, the requested user uplink rate is only 1 packet per 2 minutes. The design goal is one per minute, but we want to approach that cautiously. Also, the once a minute BText from PCSAT will always announce the expected default rate for routine mobiles using the syntax: "OPS-Normal 2m rate...." etc.

2. Understand that the PCsat mission and your objective is only to get your position and or status and or message digipeated once or maybe twice. Anything more is not being fair to other users.

3. The user uplink path is "VIA APRSAT". Like all terrestrial APRS digipeaters, PCsat will do callsign-substitution to indicate that it has digipeated the packet and the packet will come back down as PCSAT-nn*. Do not digipeat via PCSAT-nn* because it will not work in OPS-NORMAL mode. * 12 OCT Revision: The user uplink is VIA W3ADO-1 at 1200 baud on VHF or W3ADO-2 at 9600 baud on UHF.

4. Use only the authorized power levels, channel and periodicity for your station class and precedence as posted and published below.

STATION CLASS	PWR	BAUD	UPLINK	PERIOD	DIGIPATH	DOWNLINK
Legacy Packet	50W	1200	145.825	5 min	W3ADO-1*	145.825
APRS Base Stn	50W	9600	435.250	5 min	W3ADO-2*	145.825
Mobile	50W	9600	435.250	various	W3ADO-2*	145.825
Handi-Talkie	5W	1200	145.825	various	W3ADO-1*	145.825
					* 12 Oct Temp revision	

5. Use a TXD of about 200ms if possible.

6. Use the shortest possible packets. Mic-E protocol or APRS compressed is preferred (typically 30 bytes or so).

7. Determine your own precedence based on your current communications requirements for each pass. In general, all use is routine except for special circumstances. Typical Special usage is for demonstrations, and long-term events. Priority usage may be for VIP demos pr special one-time events. Use good judgment, being fair to all other users. To alert other users to your precedence/priority, set your period and position comment as follows:

STN CLASS	PRECEDENCE	PERIOD	ICON	POSITION	COMMENT
Mobile/HT	Emergency	0.2 min	any		EMERGENCY
Mobile/HT	Priority	0.5 min	any		PRIORITY
Mobile/HT	Special	1 min	any		Special
Mobile/HT	Routine	2 min	any		Off-duty, enroute, etc.
Legacy Pkt*	ALL	X * 2	N/A		Short B Text
Base Stns	ALL	X * 2	House		Off-Duty
GPS Traker	ALL	X * 2		GPSxyz	N/A

Notice that legacy packet stations, base stations, and NMEA Trackers are requested to minimize QRM by setting their packet rates to the next longer period (twice as long) for any given precedence to account for their longer packets.

8. Free hours are between 2300 and 0800 local time. During this period, any meaningful experiments may be conducted via PCsat that are conducted with good practice in sharing the transponder with other users.

SAFE MODE: Whenever PCsat RESETS to *safe mode*, we ask that all user transmissions other than Emergency and Priority traffic cease. SAFE mode can be recognized by these items:

1. If either BText says "US Naval Academy Prototype Comm Satellite..."

2. If you see the callsign W3ADO-1 or -2 on 145.825 or 144.39

3. If you hear the callsign PCsat-11 or -12 on 145.825

4. If you see the Bulletins drop back to "Default LT#.."

If PCsat is in SAFE mode, as determined by these criteria, then stop transmitting on the uplinks unless you have emergency or priority traffic. *12 Oct Revision: Continued operation in safe mode via W3ADO-1,2 is authorized.

ACCEPTANCE: If you accept the conditions of operation for PCsat, please sign this document and post it in your primary wallpaper location.

SIGNATURE: _____ Date: _____

Figure 4: PCsat User Service Agreement as of 09 October 2001 and asterisked as a temporarily revision as of 12 October 2001. (by Bob Bruninga, WB4APR)

linearity and make it fit in something the size of a cigarette pack and draw minimum power. Audio output level of a milliwatt or so is all we would need. This kind of transponder has all the advantages of the FM birds (for easy downlink) yet all the bandwith to support LOTS of simultaneous QSO's using PSK-31.

References and WWW Sites

Bruninga, Bob; "The PCsat Mission," *Proceedings of the 19th AMSAT-NA Annual Meeting and Space Symposium*, October 2001.

PCsat WWW page: http://ww.ew.usna.edu/~bruninga/pcsat.html

ISS-APRS FAQ: http://www.ew.usna.edu/~bruninga/iss-faq.html

CUBESAT Designs: http://ww.ew.usna.edu/~bruninga/cubesat.html

APRS LIVE pages: http://www.ew.usna.edu/~bruninga/aprs.html

APRS SATELLITES: http://ww.ew.usna.edu/~bruninga/astars.html

MIM/Mic-E/Mic-Lite: http://www.toad.net/~wclement/bruninga/mic-lite.html ■

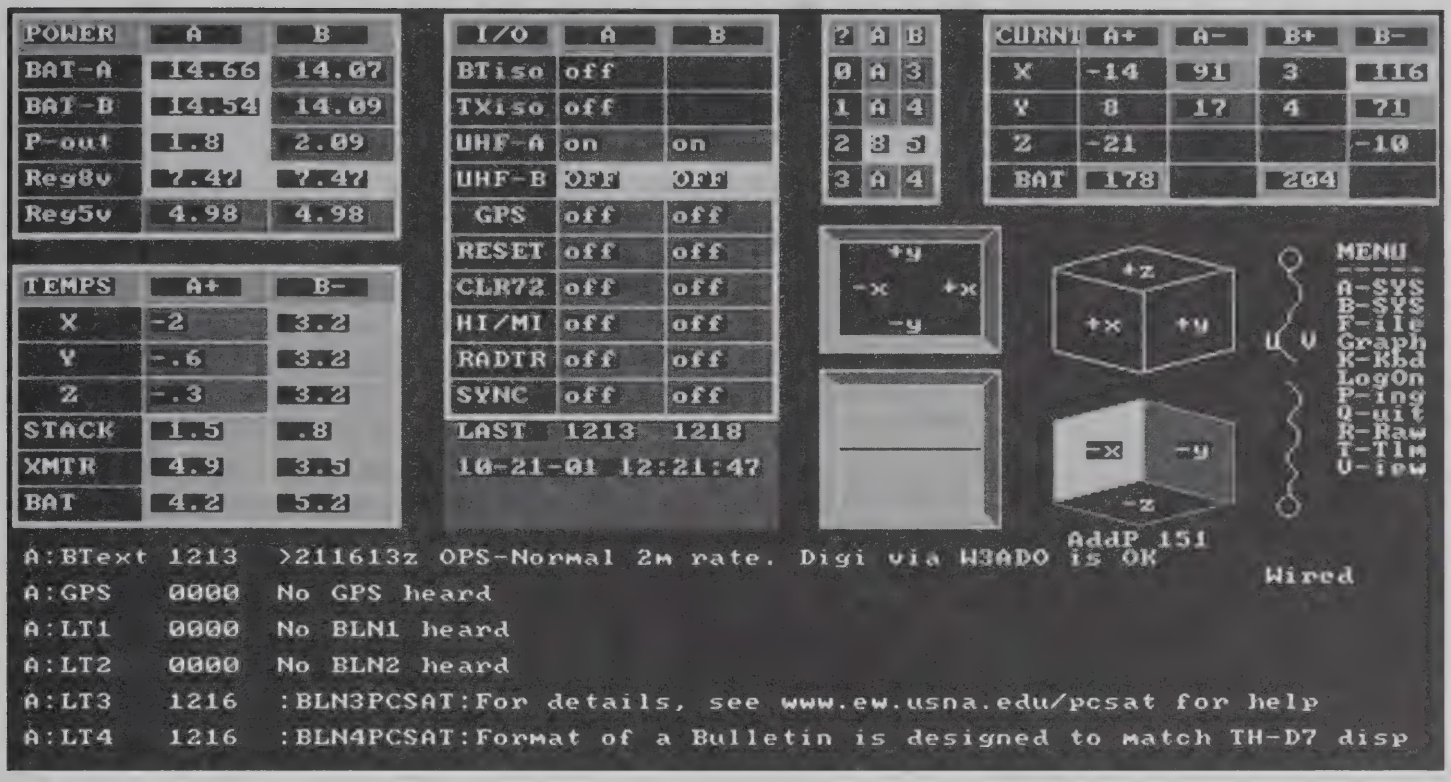


Figure 5. PCSAT telemetry screen during periods of maximum eclipse cycles (35 minutes eclipse and 65 minutes of sunlight). This figure was taken at 1621UTC on 21 October 2001, 20 minutes or 1/3rd into orbit of sunlight. Notice the still cold temperatures, low battery voltage, and high charge current of 178 and 204 mA. Also note that the UV string is separated.

Field Ops Update: 2001 Recognition

Barry A. Baines, WD4ASW, VP-Field Operations (e-mail: *wd4asw@amsat.org*)

The 2001 AMSAT Symposium provided an outstanding forum for AMSAT to recognize our hard working volunteers in Field Operations and other areas of our organization and to celebrate their successes and achievements over the past year. AMSAT's insistence on taking the time to recognize these individuals at the banquet is one of the highlights of the Symposium for me as I am always amazed by the scope of accomplishments of our members. I find these stories both impressive and inspiring. On page 5 of this issue you will find a listing of award recipients and their citations from these other departments. Congratulations to these individuals on their accomplishments and their contributions to AMSAT.

Our Field Operations Team has accomplished a great deal this past year. Much of our efforts have been aimed at providing support materials by providing Version 2 of the Area Coordinators Toolkit on CD-ROM, which is now used by Area Coordinators to enhance our ability to spread the word on working the satellites. The Toolkit contains a number of Power Point presentations and other supporting materials covering a wide variety of satellite topics. We've also made it easier for other organizations and individuals to identify a Local Area Coordinator that is located near to them by accessing our Area Coordinator Listing on the AMSAT web site. In addition, AMSAT once again provided a Satellite Workshop at a major ARRL Convention (Riverside, CA), which was well attended (over 75 registrants). Clearly, there continues to be strong demand for satellite information. There is also a strong need to publicize the fact that AO-40 is functional and that it is relatively easy to configure a 2.4 GHz downlink capability in order to hear the satellite. This emphasis on enhancing our ability to educate and publicize AMSAT is reflected in the individuals who were nominated by Field Operations for recognition in 2001.

Below are listed the recipients (in alphabetical order) who were recognized for their contributions to Field Operations along with their citation:

Steve Bible, N7HPR: *Thank you for volunteering to be a primary presenter at the ARRL/AMSAT Satellite Workshop during the 2001 Southwest Convention at Riverside. Your willingness to teach others about satellite communications with an emphasis on digital communications is commendable. Your enthusiasm coupled with your ability to explain concepts clearly makes an effective combination for encouraging future operators as well as reflects well on AMSAT itself. AMSAT expresses its appreciation and thanks for your efforts.*

Larry Brown, K7LB: *Your willingness to help AMSAT despite your busy professional work schedule continues to be impressive. In October 2000, you drove almost 2000 miles roundtrip to represent AMSAT at the 2000 Pacificon when the volunteer who was set to give a talk on Phase 3D could no longer attend. Not only did you wow the audience with an excellent talk, but you also ran an outstanding AMSAT booth that was very popular with attendees. Most recently, you volunteered to take assume a leadership role for AMSAT at the 2001 Southwest Convention of the ARRL when you agreed to do a 'satellite workshop' on Friday, September 7. Your enthusiasm for teaching others how to work the satellites was evident in your presentations. Your contributions to the International AMSAT Information Net also deserve recognition. As Assistant Net Control, you help others by coordinating check-ins, answering queries, and building enthusiasm. Despite a very busy schedule, you seem to find time for AMSAT at different levels. Thank you for your continuing strong support of AMSAT.*

Richard Crow, N2SPI: *Many thanks for stepping forward to take the lead on representing AMSAT at the 2001 Rochester Hamfest. Your willingness to tackle this responsibility, even though you had never previously been in charge of booth operations, resulted in an outstanding opportunity for AMSAT. Thanks to your efforts, the organization had a presence at this well attended hamfest after a five-year absence. Thank you for putting AMSAT back at this important event. Please accept our thanks and gratitude of AMSAT for your contribution.*

Terry Douds, N9KI: *One of the major success stories for Field Operations this year has been the distribution of the Area Coordinator Field Operations Toolkit. Every active Area Coordinator received this CD-ROM containing Power Point presentations on AO-40 and ARISS, and an introductory presentation on satellites. It also contains WAV files, the AC Listing, and other supporting materials. Your support and willingness to duplicate the CD-ROM, greatly facilitated its distribution to our Field Operations volunteers. AMSAT expresses its appreciation and thanks for your efforts.*

Bdale Garbee, KB0G: *As part of the AMSAT Forum at the 2001 Hamvention, you gave an outstanding presentation on ground station requirements for AO-40. Your enthusiasm for the subject was infectious, and the audience responded well not only to the presentation but also the 'show and tell' items that you passed around the room as well. Thank you for sharing your knowledge and enthusiasm with the attendees at the Dayton Hamvention 2001. Your time and work in support of a successful launch campaign at Kourou is also greatly appreciated. AMSAT wishes to express its sincere thanks for all of your many efforts.*

Chas Richard, W4HFZ: *Your commitment to develop a process for making the current Area Coordinator Listing available on the AMSAT Web Page has created a significant benefit for Field Operations. Not only were you willing to place this information available on our web site, but you took the time to learn how to convert this information to HTML in order to accomplish this task. You also worked with Jim Sanford, WB4GCS to ensure that he was in position to provide uploads to the AMSAT site when needed once you developed the appropriate process. Your dedication to fulfill a longtime goal of Field Operations to broaden the availability of this information while you were in the midst of a very busy schedule with the US Navy is certainly appreciated. AMSAT expresses it appreciation and thanks for your efforts.*

Jim Sanford, WB4GCS: *Over the past year you have made several significant contributions to Field Operations. Last Fall you were instrumental in the development of Version 1 of the Area Coordinator Toolkit. More recently, you played a critical role in developing a reliable process for uploading the latest Area Coordinator information to AMSAT's WWW page. The benefits of having this information available on our web site is reflected in the increased number of queries that Field Operations has received since this information was first posted. Your willingness to perform this service and coordinate with Paul Williamson, KB5MU the uploading of our latest information is appreciated. AMSAT wishes to express its appreciation and thanks for your efforts.*

What has always impressed me about Field Operations Team is the breadth of expertise and the willingness of our volunteers to step forward to help AMSAT. These particular individuals were able to find ways to contribute their time and talent to AMSAT in such a way as to meet a significant need and have fun doing it in the process. Just as important, several of our recipients were successful because they took the time to do something new and thus benefited personally as much from the experience as AMSAT grew by it. As documented in the citations, let's take a moment to reflect on the variety of ways that our volunteers made a significant impact to AMSAT and note that we had volunteers who:

a. Established the Field Ops Area Coordinator listing on the AMSAT web site by developing the necessary processes to make this material available;

b. Developed PowerPoint presentations or made available WAV files for inclusion in our Area Coordinator Toolkit;

c. Provided the resources to reproduce on CD-ROM Field Ops resources for distribution to the Field Ops Team;

d. Shared their knowledge and enthusiasm with others through creation of presentations and serving as a presenters at Dayton and at an AMSAT Satellite Workshop;

e. Stepped forward to take the lead on representing AMSAT at a major hamfest which created needed visibility even though the individual had never been in charge of a booth operation previously; and

f. Helped to manage an AMSAT net in order to share information and serve as an Elmer to newcomers.

AMSAT has benefited from those members who find ways to utilize their interests and talents to help AMSAT and others. These individuals saw a need and took the necessary steps to fulfill that opportunity even if they did not necessarily have the technical skills at the beginning of the project. In at least one case, a volunteer took it upon himself to learn a new skill necessary to accomplish the task and then created from scratch the processes necessary to provide a valuable service to AMSAT. Meeting a need of AMSAT was the catalyst for developing a new skill. Note also that their contributions were varied and could be done as time was available to complete the task.

As noted in past years, our celebration of 'success stories' by acknowledging the accomplishments of a few volunteers is meant in part to highlight not only the fact that a wide variety of skills/talents are needed, but to note that there are many volunteers who are making a difference. Clearly there are many other individuals who were not recognized this year whose efforts are also making a difference for AMSAT. However, by putting the spotlight on a few individuals each year, we all have the opportunity to celebrate our successes as an organization. We also publicize these successes in part to serve as a motivation for the rest of us step up the plate. Please reflect on what you consider to be your interests and talents and identify how you can make a difference for AMSAT as well. If you are an AMSAT-NA member who is interested in participating in the Field Organization, please do not hesitate to contact me. ■

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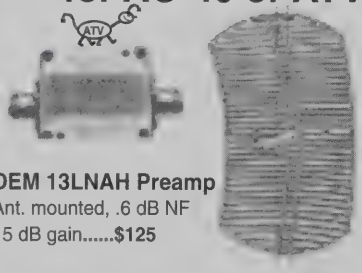

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To Mars with Phase 5A

Karl Meinzer, DJ4ZC

Translation by John Bubbers, W1GYD

Editor's Note: This article originally appeared in the September-November issue of AMSAT DL Journal. Part II of this article will appear in the next issue of The AMSAT Journal.

After the launch of AMSAT-OSCAR-40 the question for the satellite builders of AMSAT is which future projects should be approached.

Although not all systems on AO-40 operate as hoped for, there will be those interested in building a smaller Phase 3 satellite as a replacement for AO-40 on the VHF/UHF bands. At the same time there are considerations which have reached a concrete stage about the feasibility of a planetary mission by AMSAT. In this article I would like to open a discussion with our members about the future of AMSAT's goals.

Background

During the construction phase of Phase 3D it became clear that the Phase 3D structure is in the position to achieve very high propulsion power with the built-in rocket propulsion systems (delta v) and these are sufficient to carry out interplanetary missions. AMSAT-DL had a so-called 'kick off' meeting in Marburg in 1996 for a satellite (Phase 5A) which could be put into an elliptical path around Mars. *(Editor's Note: See page 26 of the September/October 1996 issue of The AMSAT Journal.)* In the first instance it was decided to canvas the interest for such a mission. The project proposal found a surprisingly large resonance, and concrete proposals for such a project were drafted. Because of the delays in the Phase 3D program the early efforts had to wait, and only after the launch of AO-40 could the earlier works be resumed. After the reactions which I have received this year, the interest for such a mission has, in the meantime, become greater, especially with the younger people.

At the 1996 meeting it became clear that there was a large demand for a relay station on Mars; there are many Mars missions planned, all of which have the same problem, to bring their data back to the Earth. Actually the radio paths to the earth are quite difficult, and Amateur Radio could play a key role, in that it could offer a service with a satellite in orbit around Mars, similar to the beginnings in Amateur Radio.

Such a mission requires money which can certainly not be raised from AMSAT or from Amateur Radio. However, since such a project finds interest for many reasons from other institutions, and the ability to finance such a mission appears to be a smaller problem, if it remains in the scope of customary AMSAT projects.

The Challenges

A mission to Mars presents insignificantly larger demands than the construction of Phase 3D; the space vehicle is actually less complex than Phase 3D. The challenges lie, rather, in the mastery of the communication paths and the flight path. The distance between the Earth and Mars is between 70 million km and 325 million km, and Mars is thereby about 2,000 to 10,000 times as far as our Phase 3D satellite. In light of that, the radio path is up to 80 dB (!!!) more difficult. One could say that radio amateurs could not seriously carry out such a mission. I would like to demonstrate that this is not necessarily so.

At these gigantic distances to Mars the space vehicle must be navigated precisely even to arrive at Mars. A distance measuring technique was developed for the Phase 3D project, which with comparable developments, could play a key role.

As already mentioned, the satellite itself does not have to be more complicated. But after it was discussed, that AMSAT was thinking about such a mission, a number of suggestions were received, as to what interesting things one could do which such a satellite to Mars. Certainly it would pay to include such experiments in the plans.

In the first part of this presentation I would like to illustrate more fully the flight path to Mars and to discuss the requirements for operationally certain radio paths from and to the satellite. In a second part I will discuss a space vehicle proposal, which is derived from Phase 3D and to present suggestons for different experiment.

The Flight Path to Mars

At the Phase 5A discussions until now, we came away with the conclusion that only Arianne 5 could be considered as the most cost effective launch possibility; as an orbit in a secondary payload it means that we can achieve only one geo-stationary transfer path (GTO) and we have no influence on the precise launch time. As mission goal we have assumed that we would like to achieve an elliptical orbit on Mars without detailed requirements, since this is possible with the least energy expenditure.

The Earth orbit is in a near circular path at about a distance of 150 million km around the Sun; Mars' path is somewhat more ellip-

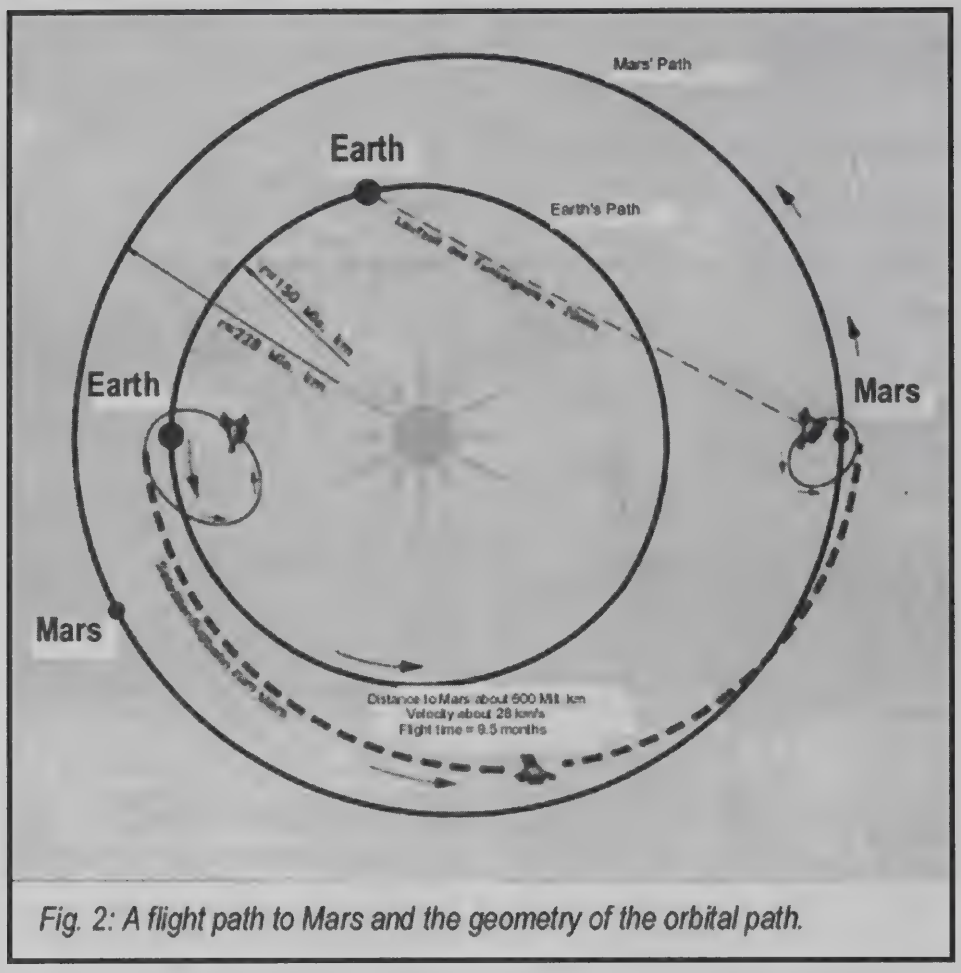


Fig. 2: A flight path to Mars and the geometry of the orbital path.

Fig. 3: The 20 m radome at the IUZ, Bochum, Germany

tical and in the middle is about 220 million km from the Sun – both paths are only a little bit inclined to each other.

As is well known, for example, one modifies the Earth's satellite paths, in which one achieves an intermediate elliptical path, which borders on the respective exit path and the desired path. Hohmann has shown in the 1930's that this method is optimal (with the least driving energy required), if the changes are not too extreme.

In a flight to Mars one proceeds exactly the same way, except that here the central body is the sun. One leaves the path of the Earth around the Sun, in that one increases the path velocity somewhat. One borders on the resultant ellipse the path of Mars at its farthest point from the sun after about 9 months of flight time. At this point one accelerates the satellite once more and thus flies further toward the Mars-orbit around the sun. With these occurrences two complications arise:

- When one arrives at the Mars path, Mars must also be there.

- At the take off from the Earth one finds oneself in an Earth orbital path, and at the arrival at Mars one wants also to be in an orbital path

The consequence of the first is that one cannot fly from the Earth at one's liking, but one must wait until the flight time for the Mars path and the Mars position fit together. This geometry is *right* about every two years and leads to the fact that one has a 'start window' every two years in which a take off from the earth is possible. Because the Mars path is somewhat elliptical and is somewhat inclined relative to the earth's path, these windows are not all of equal value. It indicates that there are windows, which require more or less propulsion energy. Unfortunately the windows in the years 2005 and 2007 are especially poor, and therefore, a mission in these years can only carry along distinctly smaller payloads to Mars.

If one calculates the velocity changes of the satellite, which are required to both leave the Earth's path and to reach the Mars path, one arrives at values of 2.5 to 3.0 km/s for both maneuvers. With simple considerations one could also say that a driving force of about 5 to 6 km/s is required. With a satellite of the Phase 3D type one can only actually achieve 2.5 km/s, and such a flight doesn't seem feasible.

Actually we are already in a path around the Earth. At closer examination it can be shown that the energy leap of physics comes to our aid: if one accelerates the satellite at perigee,

about 1 km/s is needed to leave the Earth's orbit and to *take with* about 3 km/s. This is the result of the high velocity at perigee and of the fact that the energy is a quadratic function of the velocity.

The same trick can be used during the arrival on Mars: one flies in a path that passes close to Mars, and at this point one brakes the velocity down to where one enters into an elliptical path around Mars. Using this maneuver in reducing the velocity requirement, the Phase 3D satellite has enough propulsion power.

Unfortunately, the problem of the flight path is not fully solved. If one wants to leave the Earth path, the ellipse must have the right attitude, so that the take off velocity and the direction indicates the right direction. The GTO-ellipse attitude results from the exact launch time and can therefore not be determined by us; besides, the ellipse is rotated over time by path perturbations.

In the past years this problem has been fully examined, because other missions would like to use the GTO as a cheap launch. Penzo has found a solution to this problem. It is based on one or more moon flybies to modify direction, in order to achieve a required *Epoch Synchronization*. In practice it means that eventually one could wait several months for the launch window; little additional propulsion energy is required for this maneuver.

In summary it can be stated that it is possible to fly to Mars with a 2.5 km/s delta-v and to enter into an elliptical path. To arrive at this point the mission would be about one year.

The Communications Paths

A flight to Mars is basically possible with a satellite of the Phase 3D type from the standpoint of the propulsion technology, so the question arises, which problems can be solved in practice. The great distances and the related problems of the communications paths present themselves as the central problem to accomplishment of such a flight.

The extended losses for direct sight of most radio communications are of minor importance on Earth. A careful analysis with the great distances to Mars is required in order to construct fully functional communications paths. We take a small detour, therefore, into the fundamentals of the radio path designs.

Two formulas are important for the analysis of the radio paths: The path losses between two isotropic antennas over the distance E is expressed as:

Fig. 4: The Cassegrain reflector of the parabolic antenna. It is useable up to 24 GHz.

$$D(dB) = 22 + 20 \log (E/l)$$

(where l is the wavelength)

This formula is just another way to state that:

- the transmitter power is distributed on a spherical surface of 4 pE^2 and
- the received isotropic has an effective area of $l^2/4p$ and
- only an comparable fraction of of the transmitted power is received.

The gain of the parabolic antennas with a diameter of D is approximately

$$D(dB) = 7 + 20\text{Log}(E/l)$$

The actual path loss between the antennas is

$$D - g_1 T_{x1} - g_2 T_{x2}$$

Where g_1 and g_2 are the antenna gains and T_{x1} and T_{x2} are the transmitter powers.

(The remaining losses can be neglected or can be estimated as being 3 to 5 dB.)

Several important results arise in practice from these simple formulas for three typical cases:

1. If one uses isotropic antennas or those with constant gain at both ends, the formula for D indicates that with reduced wavelength the path losses increase; for doubling the frequency 6 dB. In this case one should select the lowest possible frequency.

2. If an antenna of constant gain is used at one end of the path (at transmitter or receiver), but the other antenna is a parabolic antenna of constant diameter, the antenna gain rises by 6 dB with a doubling of the frequency and raises up the effect of the frequency in the formula for D. In this case the path loss is independent of the frequency.

3. If parabolic antennas of constant size are used at both ends of the radio path, the gain increase appears at both antennas with rising frequency; this means that the net losses are reduced by 6 dB with a doubling of the frequency.

For the mission to Mars the 2nd and 3rd cases are important: Later it will be shown that very high antenna gains are required for space travel, and would require the largest possible parabolic antenna. The Phase 3D structure permits the construction of a parabolic antenna on its upper face. This antenna can then have a diameter of 2 m. On the ground one would likewise install a parabolic antenna, so that the 3rd case would be normal for the mission - and one would plan for the highest possible frequencies for the radio paths.

For the design of the mission, however, the following case is more critical: If the attitude control of the space vehicle can, for what-

Fig. 5: The antenna and its tower and equipemt room.

ever reason, no longer be pointed towards the Earth, one would have to fall back on omni antennas with small constant gain. It is important that the command operation remain feasible, in order to not lose contact with the space vehicle. In this case the path loss is independent of the frequency (case 2 above).

In the above basic considerations the choice of frequencies has been presupposed, which has no actual meaning except for the path loss which influences the frequency choice. Actually, there are four further factors.

1. The effective noise temperature. Technology of the devices for receiver inputs has become so well developed that the effective noise temperature of the sky determines the actual attainable receiver sensitivity. In the frequency range of 1 GHz to about 12 GHz the sky temperature has a flat minimum, and this is the preferred frequency range from a noise consideration.

2. The power and efficiency of the transmitter. The efficiency falls off with increasing frequency with semiconductors. At higher frequencies, however, there are several things that address using travelling wave tubes in the space vehicle, which have good efficiency to above 12 GHz. But this matter indicates not to use frequencies above 12 GHz.

3. With increasing frequency the diameter beaming of the antennas increases. A 2 m antenna on the satellite at 12 GHz has a beamwidth of about 1°, and this is about the limit that is still attainable by our attitude control.

4. Frequency stability. Control of frequency stability above 12 GHz becomes problematic, especially at lower data rates

In summary, one can say: If one limits the frequency considerations to the range of 1 to 12 GHz, the effective path loss is in the fact of the actual design size, and the other factors similarly have a lesser meaning.

After this excursion into the fundamentals of the radio path design we can now approach our concrete problem, namely to examine how the radio paths will operate in a space vehicle to Mars.

Next one needs to consider those available frequencies in question. Because of the previous decisions the following are available: 10.5 GHz, 2450 MHz and, for reasons of complete understanding, 435 MHz; as a *worst case* a distance of 375 million km will be assumed. Additionally, antenna gains for antennas with a diameter of 2 meters and 12 meters will listed and the total loss for several practical cases. (Table 1.)

These loss values are not yet fully determined; of interest to us are the transmittable data rates. For this, further assumptions are needed, and one must distinguish between uplink (to the satellite) and downlink (from the satellite).

The following conditions for the downlink are assumed:

1. The transmitter power is 100 Watts.

2. PSK encoding is used, which arrives at 5 dB Eb/N.

3. The noise temperature of the receiver is 100K.

These values are quite conservative, but since the remaining smaller losses are ignored, they are a good basis for planning. With these figures it shows that a maximum loss of 223.6 dB is permissible for 1 bit/s.

From Table 1 it immediately follows that in the case of the 5 dBi antenna on the satellite and the 20 meter ground antenna there is only 8 dB margin; that means that under these conditions a data rate of 6 bits/s can be achieved under the best conditions. The choice of frequency is of no consequence in this case. This is the emergency situation, if the attitude control does not aim the 2m diameter antenna toward the earth.

With the 2m diameter antenna on the satellite and a 20m ground antenna, the situation appears much better: There is a margin of 47 dB, which supports a data rate up to 5,000 bit/s on 10.5 GHz. In fact, this margin permits the reception of up to 500 bit/s with a 2m diameter ground antenna.

However, these figures are only valid for a 10.5 GHz downlink; at 2.45 GHz the data rate sinks to 2800 bit/s with the 20m antenna and on 435 MHz to 85 bit/s. This means that with the 2m ground antenna on these frequencies data rates of only 28 bit/s (2.45 GHz) and less than 1 bit/s (435 MHz) are possible. This demonstrates the large advantage of the choice of 10.45 GHz as downlink.

The 2.45 GHz uplink (the first choice for the

command channel) would be preferred – because with the other frequency ranges there are fewer opposing influences to be anticipated, and the critical case without attitude control is not frequency dependent. As transmitter power one can, for example, estimate 1 kW (synchronized microwave oven magnetron)- the other prerequisites are similar as those for the downlink. Losses up to 233.6 dB are permissible for data rates of 1 bit/s.

For the emergency condition (loss of attitude control) up to 80 bit/s for command operation are possible with the 20m ground antenna. One would actually provide for greater safety margins and for this case reduce the data rate to 10 bit/s.

In any event, the data rates would be reduced to 1 bit/s with 2m antennas, a data rate that is operationally barely acceptable. Thus, a 20m antenna is definitely needed for the execution of the Phase 5A mission at least for a margin of safety. If the attitude control aims the satellite to the earth, 100 to 200 bit/s can be transmitted by 2m antennas; this means that for routine command operation the 2m ground antennas are sufficient.

Because of the need to have a large antenna available for the mission, AMSAT-DL made a suitable agreement in 1997 with the management of the Bochumer 20m antenna. Currently the antenna, which was built in the 1960's, is being equipped for newer requirements. There is the agreement that it will be available on priority for the Phase 5A mission, if such a space vehicle is launched. Because of the difficult paths to Mars it seems desirable to make accessible the 2m antenna and also other antennas with a diameter of 2 to 3 m diameter over the internet in order to make it available to a larger number of users. AMSAT would prefer to have the command operation removed from the antennas, and the result for the radio amateur is the challenge, to become involved in the operational and technical proposals. A large part of the technology and also of the operational technique can be developed and tested on AO-40.

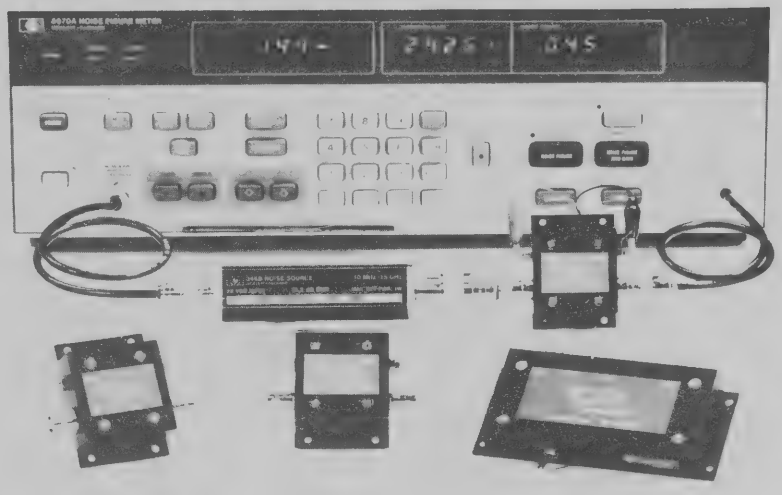
Summarizing, it can be said that despite the radio limitations of a Mars mission it is still achievable, especially by including the Internet, but for emergency situations a large antenna must be available.

In the second part of this presentation the obvious problems of the construction of the Phase 5A satellite will be discussed and also some interesting experiments for this satellite will be presented.■

Table 1.

	10500 MHz	2450 MHz	435 MHz
d (375 million km)	284.4 dB	271.7 dB	256.7 dB
g (2m)	43.9 dB	31.3 dB	16.2 dB
g (20m)	63.9 dB	51.3 dB	36.2 dB
s (2m on Sat, 20m Ground)	176.6 dB	189.1 dB	204.3 dB
s (2m on Sat, 2m Ground)	196.6 dB	209.1 dB	224.3 dB
s (5 dBi on Sat, 20m Ground)	215.5 dB	215.5 dB	215.5 dB

High Performance vhf/uhf preamps



Receive Only	Freq. Range (MHz)	N.F. (dB)	Gain (dB)	1 dB Comp. (dBm)	Device Type	Price
P28VD	28-30	<1.1	15	0	DGFET	$29.95
P50VD	50-54	<1.3	15	0	DGFET	$29.95
P50VDG	50-54	<0.5	24	+12	GaAsFET	$79.95
P144VD	144-148	<1.5	15	0	DGFET	$29.95
P144VDA	144-148	<1.0	15	0	DGFET	$37.95
P144VDG	144-148	<0.5	24	+12	GaAsFET	$79.95
P220VD	220-225	<1.8	15	0	DGFET	$29.95
P220VDA	220-225	<1.2	15	0	DGFET	$37.95
P220VDG	220-225	<0.5	20	+12	GaAsFET	$79.95
P432VD	420-450	<1.8	15	−20	Bipolar	$32.95
P432VDA	420-450	<1.1	17	−20	Bipolar	$49.95
P432VDG	420-450	<0.5	16	+12	GaAsFET	$79.95
Inline (rf switched)						
SP28VD	28-30	<1.2	15	0	DGFET	$59.95
SP50VD	50-54	<1.4	15	0	DGFET	$59.95
SP50VDG	50-54	<0.55	24	+12	GaAsFET	$109.95
SP144VD	144-148	<1.6	15	0	DGFET	$59.95
SP144VDA	144-148	<1.1	15	0	DGFET	$67.95
SP144VDG	144-148	<0.55	24	+12	GaAsFET	$109.95
SP220VD	220-225	<1.9	15	0	DGFET	$59.95
SP220VDA	220-225	<1.3	15	0	DGFET	$67.95
SP220VDG	220-225	<0.55	20	+12	GaAsFET	$109.95
SP432VD	420-450	<1.9	15	−20	Bipolar	$62.95
SP432VDA	420-450	<1.2	17	−20	Bipolar	$79.95
SP432VDG	420-450	<0.55	16	+12	GaAsFET	$109.95

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S-Band Tips, Tricks, & Toys

Gerald R. Brown, K5OE

Many of us *newbies* to the world of microwaves have discovered the tools, accessories, and methods so common to us in the HF/VHF world are either non-existent or inadequate at these elevated frequencies. Over the last year or so I have experimented quite a bit on S-band, learned a little, and accumulated a few tools and tricks to share with you. None of these will cost you much and some of them will make your life on 2.4GHz much easier, safer, and more enjoyable.

Crystal Calibrator

This diminutive device, rare in today's world of PLL-controlled radios with digital readout of frequency to tens-of-Hz, is indispensable in finding your "blind" downconverter's frequency. I was perusing the International Crystal Manufacturer (ICM) web site prior to ordering some crystals for a downconverter project and noticed they listed inexpensive, self-contained crystal oscillators in various useful frequencies (*http://www.icmfg.com/instock.html*). I chose the 31421, a 5MHz oscillator for $3.80 each and in stock (not special order), so I added it to my order. These little wonders are designed for circuit board insertion in a DIP format, so I scrounged around and found a piece of perf board and built the unit shown in Figure 1. To the basic ICM oscillator I added a 7805 regulator to supply the unit with a regulated 5Vdc, an LED for status, and a 10 kOhms and 1N4001 diode on the output to assist in harmonics generation. This is a 30 minute project and the additional parts are all available at Radio Shack. I was amazed when I first turned it on to find the signal was right on the money at 900MHz on my FT-100's display. Too easy! It puts out a nice carrier at 2400 and 2405MHz for quick and easy calibration of your downconverter. This unit is also handy for antenna system checks and calibration, but is too weak to be heard very far from an antenna.

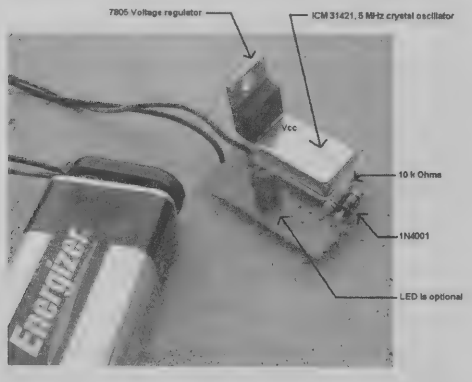

Figure 1: The ICM 5MHz Crystal Oscillator

Signal Source / Beacon

What I really needed was a signal source strong enough to aid me in testing antennas for AO-40's S-band downlink. I wanted a *source* for my own microwave antenna test range. The G0MRF kit available from AMSAT-UK looked like an excellent solution, so I ordered one of the kits via email. More on that later, because while I was waiting for my trans-Atlantic package to appear, the May/June issue of *The AMSAT Journal* arrived, and there inside was this neat project by Al Copeland, GM1SXX: "Project Duckling - or - Uses for Dead Drakes," on pages. 8-9. Basically, it was a salvage project for junk Drake 2880's. I just happened to have one of those *dead Drakes* sitting on my bench. The Drake's local oscillator uses a crystal and a multiply-256 chain and I wanted a signal source in the middle of the S2 band at 2401.500MHz for antenna testing, so I simply did the math: 2401.500 / 256 = 9.38086. I ordered a "Drake" crystal from ICM, part number 540289, (HC-49/U, .400 height, FX=7.5-9.999MHz) except specified the frequency to be 9.38086MHz. When the crystal arrived, I followed Al's instructions except I re-used the original Drake case. I calibrated my duckling for 2401.500MHz using the original LO pot and could not believe my ears and eyes: the signal was 80 dB over S9 with the duckling sitting on my bench and the antenna up on the boom 10m in the air! Wow, what a signal. See Figure 2 for my now-customized duckling, complete with on/off power switch and status LED.

Figure 2: My Project "Duckling"

I use this device every time I work AO-40. I simply switch on the duckling and see where the downconverter (out in the hot South Texas sun) reads the frequency and add/subtract the delta from 2401.500 to my computer's display of the current beacon frequency (I usually use my Uni-Trac display). With this reference signal, I can include the actual temperature-drift-offset of the downconverter into my up/down calculation—works like a champ to get my uplink right on frequency.

The G0MRF kit is much smaller than the duckling and it puts out an equally impressive signal a little lower in the AO-40 passband. The assembled kit fits easily inside a small can to focus the signal for a beacon or antenna testing. You can order it here: *http://www.g0mrf.freeserve.co.uk/source2.htm.*

Preamp Power Modifications

If you want to use a preamp with your downconverter, powering it can be inconvenient if you run the power for the downconverter up the coax. Several options exist for tapping into this power in the coax, including adding a coax tee ahead of the downconverter, but these solutions usually require some kind of external connection to the preamp. I really wanted a more elegant solution for this problem since both my DEM and my Conifer preamps allow power fed via the output coax. I tried modifying a Drake downconverter by tapping off the 10Vdc regulator inside the unit and connecting it to the RF input. My first attempt was a failure due to stray RF coupling with this new power wiring. David Bowman, G0MRF came to the rescue with a better solution—placing the components directly on the N-connector*: http://www.g0mrf.freeserve.co.uk/drake2.htm.* David, like many contemporary RF experimenters, has a propensity to use very small surface mount (SM) components. I have an equal penchant to avoid these miniature components whenever possible. I attempted David's mod with "normal sized" components (also available at Radio Shack) by first installing a small poly capacitor, 8 pF, between the N-connector and the circuit board strip. Next, I routed a wire from the 7810's output leg and installed a small molded inductor (RF choke) on the "outside" side of the poly cap where it meets the N-connector center pin. These two components will just fit within the notch in the RF amp cover. This mod works well and powers my DEM 13ULNAK preamp flawlessly. You can

see David's crafty original mod at his aforementioned WWW site. Figure 3 shows a close-up view of my Drake mod; Figure 4 depicts a similar mod I installed on a TSI 3733; and Figure 5 depicts the mod on a Norsat 2500.

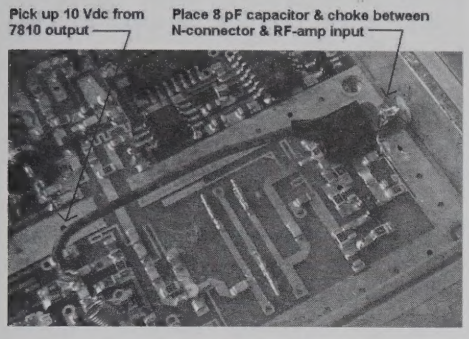

Figure 3: Preamp Power Mod for Drake 2800

Double Downconversion

My paramount safety concern with the various downconverters, other than falling off the roof, was fear of accidentally transmitting into one of them and ending up with an expensive paperweight. Remember that dead Drake? It occurred to me my main rig, a Kenwood TS-2000, has a receive-only port on HF and I could utilize this port as a safe connection for my downconverters. I had previously built a Hamtronics 70cm-to-10m receive converter kit and was familiar with these units, so I started looking for a 2m-to-10m version. After a month or so, I spotted one on eBay and picked it up for the agreeable price of $23. I then added a few "convenience" features: a power switch and status LED, a fused power input, and the power-insertion circuitry for the remote S-band downconverter. This last mod allows me to eliminate the ubiquitous bias-tee connections in the coax. Another significant benefit of this double downconversion is it frees up the 2m port on my radio for other uses, such as mode V/S for RUDAK, and for driving a future transmit converter for C-band. If you need to add an external transmit converter or transverter for L-band, which usually have a 2m IF, this double downconversion configuration allows you to free up that 2m port on your radio.

Independent Telemetry Monitoring

Ever wonder what is going on with AO-40 when signals suddenly change? Don't you wish you had a way to monitor the telemetry while you are also QSO'ing? I made one more "improvement" to the Hamtronics downconverter by adding a second output and toggle switch, allowing selection of either the 2m signal coming down the coax from the S-band downconverter or the output from the 10m receive converter. This gives me a choice of IF for a second output to monitor the beacon, hook up to a record-

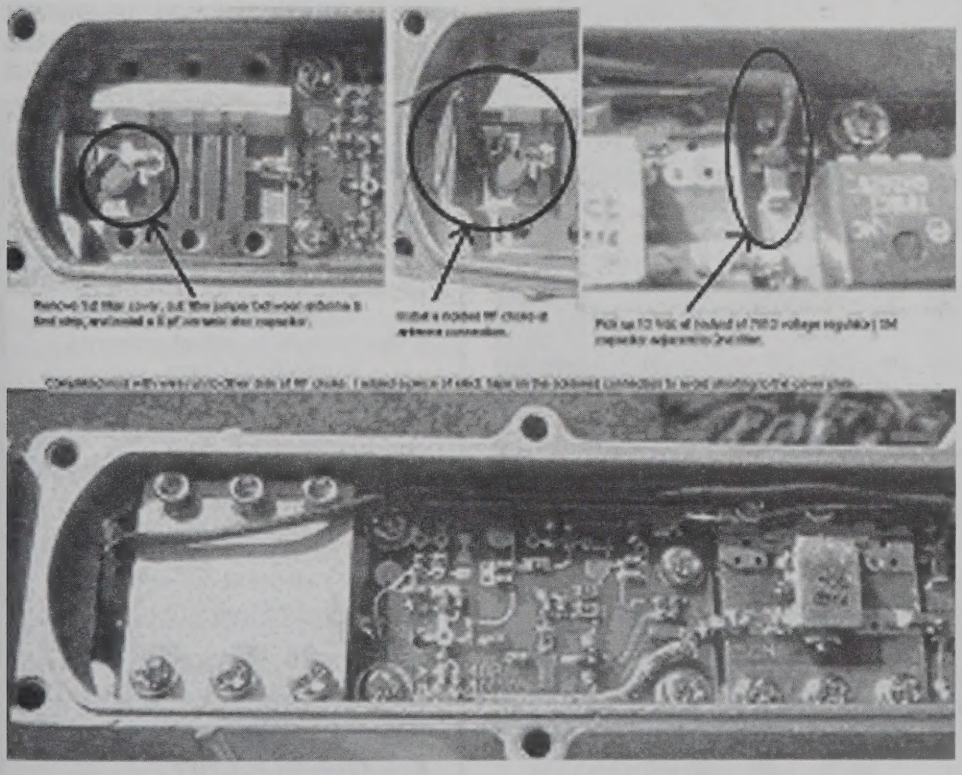

Figure 4: Preamp Power Mod for TSI 3733

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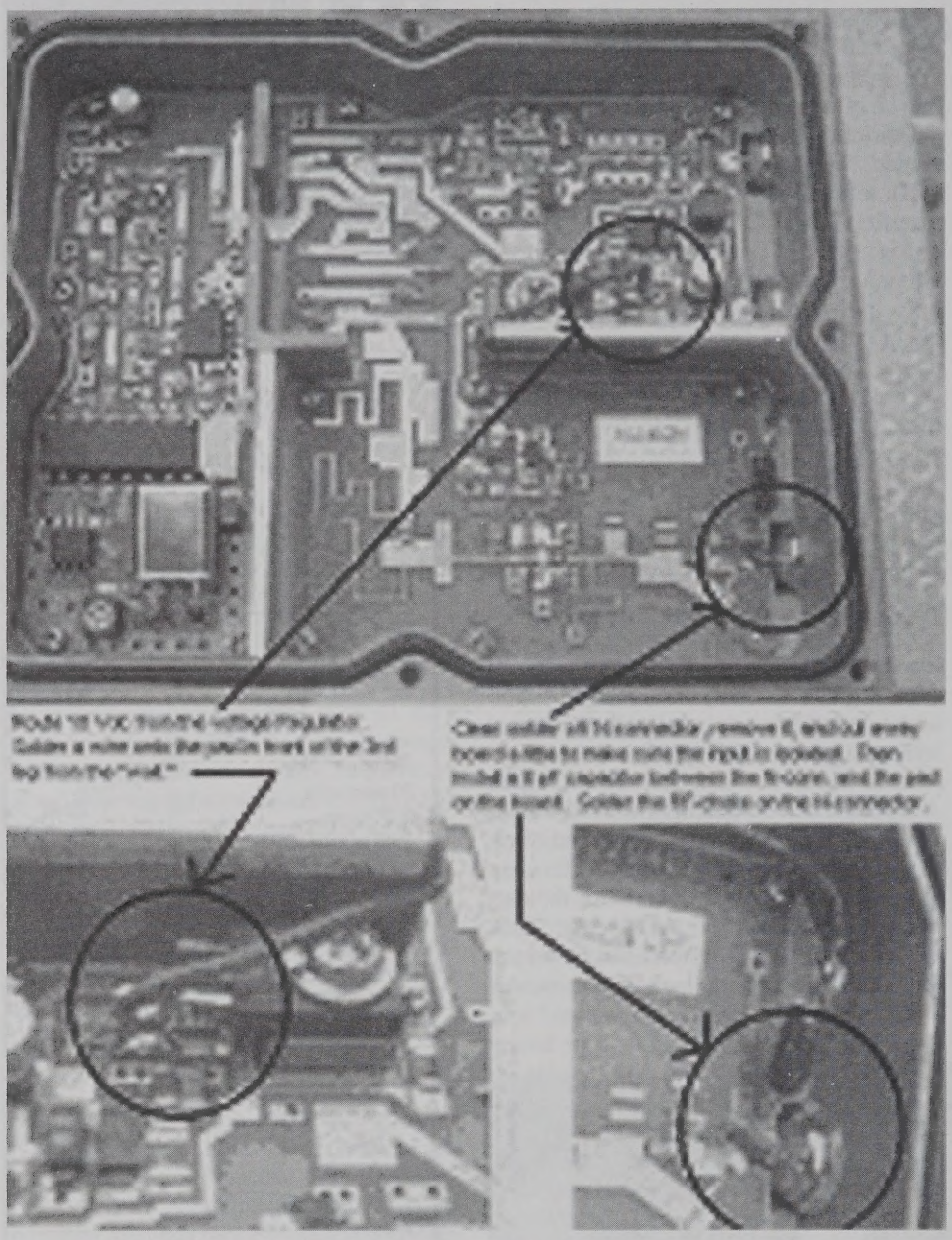

Figure 5: Preamp Power Mod for Norsat 2500

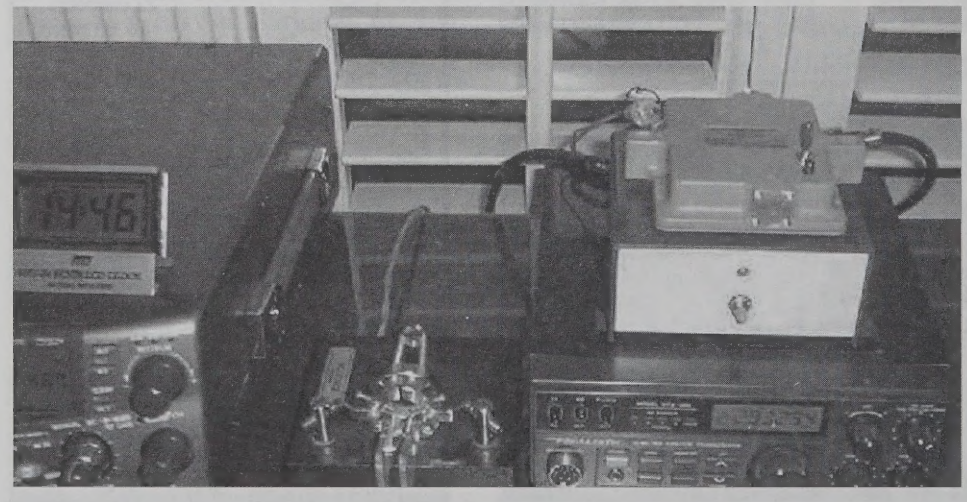

Figure 6: Full Time and Independent Telemetry Monitoring Via The Second Output

ing system, *etc.* I happened to have a transmit-crippled HTX-100 10m rig sitting on the floor of a closet (bought on eBay for $30 and used for RS-12/13 downlink). I put it into service as my dedicated AO-40 telemetry receiver. I still need to interface the mic-click controls to the AO40Rcv program for automatic frequency control, but that is a project for another day.

Remote Monitoring / Manual Pointing Aid

Do you point your antenna manually? Maybe you are considering a portable or Field Day setup. I have learned it takes too many trips to accurately tweak the antenna. What I needed was a local (to the antenna) radio to listen to the beacon so I could point the antenna accurately without making a lot of trips in and out of the shack. It occurred to me I could simply add a coax "tee" to the line between the downconverter and the shack—allowing me to hook up a portable radio in parallel with the one in the shack. You will want to add a decoupling capacitor (0.01uF will work fine) if you are not sure your portable radio can stand 12Vdc on the input. This functions just beautifully. Even an HT or scanner will work as the beacon is quite detectable on FM. Simply listen or watch the S-meter and adjust the antenna for strongest signal.

I hope you find some of the foregoing ideas useful. Maybe future commercial satellite radios will feature some of these conveniences. If you would like to access full size color pictures of any of these illustrations, please visit http://members.aol.com/k5oe and click on the "S-Band Toys" menu option. ■

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AMSAT India News

Nagesh Upadhyaya, VU2NUD reports that Radio Amateurs met on 28 October 2001 in Bangalore India to formally establish AMSAT-India as an organization for Indian amateur satellite programs. Bylaws of AMSAT-India were organized and approved including:

- Incorporating as a non-government, non-profit, and voluntary organization with the purpose of developing amateur satellite payloads, complete amateur satellites, related ground segments and amateur satellite activities in India.
- Organizing headquarters in Bangalore.
- Coordinating with International AMSAT community in support of Indian Amateur satellite endeavors.
- Developing goals that are concurrent with the Indian national space policy and national space agency (Dept. Of Space - Indian Space Research Organization).
- Establishing several committees including a core advisory committee, technical committee, finance committee, international committee, and general membership committee (consisting of eminent Hams). Nagesh Upadhyaya, VU2NUD will be AMSAT-India secretary and be responsible for convening committee meetings and other business as needed.

Later in November, AMSAT-India announced that the first working module of the VUSAT project has been delivered by Mani, VU2ITI. The Morse code generator that is major part of the TM beacon on VUSAT has been developed and the working PCB has been handed over. Testing shows it is working extremely satisfactorily and work will progress to make it space qualified. Also, Sri, VU2SBJ has informed AMSAT-India that the message beacon is ready for delivery and testing. Furthermore, the VUSAT VHF transmitter module is also getting ready for testing.

AO-40, K-Band Tx Test Successful!

Stacey Mills, W4SM reports that on Orbit 396, MA=118 to 138, AO-40's K-band (24.048 GHz) transmitter was active and connected to the same inputs as the S2 transmitter. The passband and beacon were first detected by Petra G4KGC (radio op) and Charlie Suckling G3WDG (dish op) at 1930 UTC, MA=122. Shortly thereafter the beacon and passband were also detected by Michael Fletcher, OH2AUE. The Suckling's used a 22 cm offset dish and reported signals 6 dB above the noise floor. Michael used a 60 cm dish and reported that the beacon was 7 db above the noise floor under less than ideal conditions with overcast skies and occasional rain. Both used linear feeds and reported good, stable signals except for cyclic deep fades due to the linear polarization of the K-Tx antenna, the linear polarization of their feeds, and the rotation of AO-40. A circularly polarized feed should eliminate these spin fades. The command team is delighted to report this additional functional transmitter on AO-40!!!

LtoR: Prathap/VU2POP, Nagesh/VU2NUD, Sundararamaiah/Principal Scientific Secretary, Ramesh/VU2RMS, Dr. Kasturi Rangan Chairman, Subi/VU2UV, Guru/VU2GUR, Shankar/VU2CAP, Prabhudev/VU2DEV

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